US Army Corps of Engineers
Los Angeles District

SANTA ANA RIVER BASIN, CALIFORNIA

Santa Ana River

Design Memorandum No. 1

PHASE II GDM ON THE SANTA ANA RIVER MAINSTEM including Santiago Creek

VOLUME 7
HYDROLOGY

August 1988

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This volume accompanies the Main Report and Supplemental Environmental Impact Statement for the Phase II General Design Memorandum for the Santa Ana River Mainstem including Santiago Creek and contains hydrologic information in support of the general design consideration for Seven Oaks Dam, Prado Dam, Santa Ana River mainstem between Seven Oaks Dam and Prado Dam, Mill Creek Levee, Oak Street Drain, Santiago Creek, and Lower Santa Ana River.

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Design Memorandum No.1
Volume 7
Santa Ana River Mainstem
Including Santiago Creek, California
Phase II General Design Memorandum

Hydrology

SYLLABUS

This volume accompanies the Main Report and Supplemental Environmental Impact Statement for the Phase II General Design Memorandum for the Santa Ana River Mainstem including Santiago Creek and contains hydrologic information in support of the general design consideration for Seven Oaks Dam, Prado Dam, Santa Ana River mainstem between Seven Oaks Dam and Prado Dam, Mill Creek levee, Oak Street Drain, Santiago Creek, and lower Santa Ana River.

PHASE II GDM LISTING OF VOLUMES

Main Report and Supplemental Environmental Impact Statement	
Volume 1	Seven Oaks Dam
Volume 2	Prado Dam
Volume 3	Lower Santa Ana River (Prado Dam to Pacific Ocean)
Volume 4	Mill Creek Levee
Volume 5	Oak Street Drain
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I. INTRODUCTION

Purpose and Scope

1-01 This volume of the Phase II General Design Memorandum (GDM) presents the results of hydrologic investigations made for the Santa Ana River Project in connection with flood control planning and design efforts not covered in the 1975 Review Report, the 1980 Phase I GDM, or the 1985 Supplement to the Phase I GDM, plus updating for changed conditions and new information. Primary emphasis was placed on studies concerned with recommended project elements (pl. 7-1) for flood control on Seven Oaks Dam (previously known as Upper Santa Ana River Dam), Prado Dam, Mill Creek Levees, Oak Street Drain, Santiago Creek, and lower Santa Ana River, and how the reservoir system will operate. Generally, hydrology for the Santa Ana River Project not discussed herein may be found in the "Review Report on the Santa Ana River Main Stem - Including Santiago Creek and Oak Street Drain", the "Phase I General Design Memorandum on the Santa Ana River Main Stem - Including Santiago Creek" and the "Supplement to Phase I GDM on the Santa Ana River Main Stem - Including Santiago Creek."

Previous Reports

1-02 The most recent hydrology development by the Corps of Engineers for the study area was presented in the "Supplement to the Phase I General Design Memorandum on the Santa Ana River Main Stem - Including Santiago Creek, Appendixes (Volume I)," dated December 1985. Additional hydrology was presented in the "Phase I General Design Memorandum on the Santa Ana River Main Stem - Including Santiago Creek", Technical Appendixes (B, C, D, E, and F)," dated September 1980 - and the "Review Report on the Santa Ana River Main Stem - Including Santiago Creek and Oak Street Drain, Appendix 2, Volume 2, Technical Information," dated December 1975 (hereafter called the Review Report).

1-03 Probable maximum and standard project flood inflow hydrographs for Prado Dam, presented in the report titled "Interim Report on Design Features of Existing Dams, Hydrology and Hydraulic Reviews for Prado,

Brea, Fullerton, and Salinas Dams," dated November 1969, were approved by the Office of the Chief of Engineers on May 1970 for use in further studies related to the review of design features of Prado Dam.

1-04 Hydrology presented in the report titled "Hydrology, Santa Ana River Below Prado Dam, Orange County, California," dated July 1974, was approved by the South Pacific Division in the fifth endorsement, dated July 31, 1974, for use in survey report investigations.

1-05 Hydrology for Mill Creek, presented in the report titled "Design Memorandum No.1, Hydrology for Mill Creek Levees", dated June 1958, was approved by the South Pacific Division in the first endorsement, dated 10 September 1958 for use in the design of Mill Creek levee.

1-06 The impact of improving the Lake Elsinore outlet channel on Temescal Wash and Prado Dam for the standard project flood (SPF) was evaluated in the report titled "Review Report for Flood Control and Allied Purposes, 4th Interim Report, Lake Elsinore Basin, Stage II, Hydrology", dated December 1983, hereafter called the 1983 Lake Elsinore Review Report.

1-07 The presentation of the proposed Lake Elsinore outlet channel improvement is discussed in the draft report titled "Lake Elsinore, Riverside County, California, Small Flood Control Project Authority, Technical Report, Draft", dated April 1987.

1-08 Water quality data used for this study were presented in a report titled "California Regional Water Quality Control Board, Santa Ana Region, Water Quality Control Plan, Santa Ana River Basin, 1984."

1-09 Additional water quality data which identified contaminants in Prado Reservoir are discussed in a report titled "U.S. Army Corps of Engineers, Annual Water Quality Management Reports for Reservoir Projects for Water Years: 1980, 1983, 1984, 1986, Los Angeles, California".

II. DESCRIPTION OF WATERSHEDS

Physiography and Topography

SANTA ANA RIVER BASIN

2-01 The Santa Ana River Basin drains approximately 2,450 square miles, excluding a closed area of 32 square miles tributary to Baldwin Lake and 10 square miles tributary to Perris Reservoir (pl. 7-1). Of the total basin area, 2,255 square miles lie upstream of Prado Dam, the major flood control structure on the Santa Ana River. Approximately 23 percent of the basin lies within the rugged San Gabriel and San Bernardino Mountains, 9 percent within the San Jacinto Mountains, and 5 percent within the Santa Ana Mountains. Most of the remaining area consists of lower-sloped valleys formed by a series of broad alluvial fan surfaces which abut the base of the mountain front. Numerous low foothills rise above the alluvial fan surfaces and include a range of hills north of San Bernardino; the Crafton Hills east of Redlands; the Jurupa Mountains north and west of Riverside; the Box Springs Mountains and the Badlands east of Riverside; and the Chino and Peralta Hills northeast of Anaheim. In general, mountain ranges within the basin are steep and sharply dissected. Maximum elevations in the basin reach 10,080 feet NGVD at San Antonio Peak in the San Gabriel Mountains; 11,502 feet NGVD at San Gorgonio Mountain in the San Bernardino Mountains; and 10,804 feet NGVD at Mount San Jacinto in the San Jacinto Mountains. The San Bernardino Mountains contain the headwaters of the Santa Ana River and two of its principal tributaries, Bear and Mill Creeks. Lytle Creek, the largest tributary originating in the San Gabriel Mountains, is in the northwest portion of the watershed. The San Jacinto River has its origin in the San Jacinto Mountains southeast of Beaumont. The Santa Ana River has an average gradient of about 240 feet/mile in the mountains and about 20 feet/mile near Prado Dam. The average gradients of the principal tributaries are approximately 700 feet/mile in the mountains and 30 feet/mile in the valley areas. The mountainous areas are expected to remain largely undeveloped during the entire project life. The valley areas above and below Prado Dam are presently partially urbanized and are expected to approach complete urbanization by the end of project life.

2-02 The entire Santa Ana River Basin is underlain by a basement complex of crystalline metamorphic and igneous rocks, which appear on the surface only in the most mountainous parts of the watershed. In the foothills and valleys, the basement complex is overlain by a series of sandstones and shales. Unconsolidated alluvial deposits range in depth from a few feet within the mountains to more than 1,000 feet on the alluvial fans in the valleys. The existence of several precipitous mountain scarps along the upper boundaries of the watershed indicates that the area has been subjected to extensive folding and faulting. The soils in the mountains, which are derived mainly from metamorphic and igneous rocks, are shallow, poorly developed, and stony. On the lower slopes of the mountains and foothills, soils are mainly loams and sandy loams, ranging from less than 1 foot to over 6 feet deep. In the valleys, where soils are usually more than 6 feet deep, surface soils range from light, sandy alluvium to fine loams and silty clays with heavier subsoils.

SEVEN OAKS DAM (UPPER SANTA ANA RIVER BASIN)

2-03 The Seven Oaks Dam watershed drains approximately 177 square miles, excluding the closed area of 32 square miles tributary to Baldwin Lake (pl. 7-2). The headwaters lie within the rugged San Bernardino Mountains. Elevations vary from 10,664 feet NGVD at Anderson Peak and 11,502 feet NGVD at San Gorgonio Peak to 2,060 feet NGVD at the damsite, which is approximately 1 mile upstream from the canyon mouth. Generally trending southwesterly, the 27 miles of river upstream of the damsite have an average gradient of 300 feet/mile, with individual stream gradients of 450 and 628 feet/mile for subareas A2 and A3 , respectively. However, some smaller tributaries originating in the high mountains have gradients that exceed 1,900 feet/mile. Bear Creek, the principal tributary within the Seven Oaks canyon area, comprises 55 square miles and possesses an average gradient of approximately 460 feet/mile. Well-developed growths of fir and pine occur above elevations of about 5,000 feet NGVD. Many steep slopes within the watershed are covered with a moderate to dense growth of chaparral and sage scrub. Lower slopes carry a heavy cover of grasses and forbs. The drainage area above the dam is expected to remain largely undeveloped during the project life.

MILL CREEK

2-04 The Mill Creek watershed, in the San Bernardino Mountains, has a drainage area of 52 square miles (pl. 7-3). Elevations range from 11,502 feet NGVD at San Gorgonio Peak and 9,140 feet NGVD at Little San Gorgonio Peak to 1,700 feet NGVD at the confluence with the Santa Ana River. The principal channel of Mill Creek flows westerly and possesses an average gradient of 565 feet/mile. The maximum gradients of many smaller tributaries exceed 1,900 feet/mile. Well-developed growths of white fir, ponderosa pine, sugar pine, conifers and brush, including chaparral and manzanita, are common on the steep, rocky slopes of this watershed. Grasses, sage, and scattered deciduous trees are the principal vegetal cover on slopes below 5,000 feet NGVD. Alders, cottonwoods, and willows encroach upon the stream channels at lower elevations.

OAK STREET DRAIN

2-05 The Oak Street Drain drainage area (pl. 7-4) is approximately 15 square miles. Hagador, Tin Mine, and Kroonen Canyons originate in the steep eastern slopes of the Santa Ana Mountains and combine at Riverside County Flood Control and Water Conservation District (RCFCWD) Oak Street debris basin to form the beginning of the Oak Street Drain channel. The channel extends northward from the debris basin over a wide alluvial plain, through the western portion of the city of Corona and into Temescal Wash. Flow from Mabey Canyon debris basin, Lincoln Avenue Drain, and Main Street Drain enter Oak Street Drain upstream of its confluence with Temescal Wash. Elevations vary from 3,800 feet NGVD in the headwaters area, to 1,000 feet NGVD at the RCFCWD debris basin, to 570 feet NGVD at the mouth. Channel slopes range from about 600 feet/mile in the upper basin to 200 feet/mile in the lower basin. Vegetation varies considerably within the watershed. Chaparral, sage, grasses, and scattered trees cover the mountain and foothill areas, while large segments of the valley area have been cleared of most native vegetation due to extensive development. Vegetal cover on the remaining undeveloped portions of the valley floor consists mainly of citrus and avocado orchards, field crops, and eucalyptus and sycamore trees.

SANTIAGO CREEK

2-06. Santiago Creek watershed is approximately 102 square miles in area (pl. 7-5). Most of the watershed is within Orange County, with a small portion of the headwaters in Riverside County. It flows westward through the cities of Orange and Santa Ana, and then into the Santa Ana River. Elevations in the basin range from 5,687 feet NGVD at Santiago Peak in the Santa Ana Mountains to 110 feet NGVD at the confluence with the Santa Ana River. Stream gradients range from 305 feet/mile in the upper reaches to 25 feet/mile in the lower reaches of Santiago Creek. The downstream segment of this basin is located on the coastal plain, the gradually sloping lowland apron that extends from the base of the Santa Ana Mountains to the Pacific Ocean. The watershed of Santiago Creek contains agricultural, residential, and commercial development, two dams, gravel pits, several parks, a golf course, two major railroad lines, three freeways, and many bridges. Vegetation varies considerably in the watershed. The mountain and foothill areas are covered with chaparral, sage, grasses, and scattered trees, with larger stands of trees within the floodplain areas. Large segments of the valley area have been cleared of most native vegetation because of extensive development in the area. Vegetation in the remaining valley areas consists mainly of eucalyptus and sycamore trees.

LOWER SANTA ANA RIVER BASIN FROM PRADO DAM TO THE PACIFIC OCEAN

2-07 The Santa Ana River basin below Prado Dam comprises about 208 square miles, excluding about 19 square miles tributary to Carbon Canyon Creek above Carbon Canyon Dam (pl. 7-6). The natural drainage of Carbon Canyon Creek is to the San Gabriel River with a diversion to the Santa Ana River. The project reach of the Lower Santa Ana River

(pls. 7-7 through 7-10) flows about 31 miles from Prado Dam through Santa Ana Canyon and the cities of Yorba Linda, Anaheim, Orange, Santa Ana, Fountain Valley, Costa Mesa, and Huntington Beach before emptying into the Pacific Ocean. Approximately 60 percent of the drainage area lies within the Santa Ana Mountains and the Chino Hills. Most of the remaining area lies within the broad coastal plain which extends southwestward to the Pacific Ocean. Numerous tributaries contribute to the Santa Ana River within this project reach. The principal tributary is Santiago Creek which drains an area of approximately 102 square miles. Other tributaries include Wardlow Canyon, Aliso Canyon, Gypsum Canyon, Blue Mud Canyon, Walnut Canyon, and Carbon Canyon Creek. The average gradient of these tributaries is about 300 feet/mile, while the average slope of the Santa Ana River from Prado Dam to the ocean is about 15 feet/mile.

2-08 The drainage area is underlain by a basement complex of crystalline metamorphic and igneous rock, which appear as outcrops only in the most mountainous segments of the watershed. In the foothills and valleys, the basement complex is overlain by unconsolidated alluvial deposits formed by fluvial geomorphologic process. The soils in the mountains are generally shallow and stony, being derived mainly from the weathering and erosion of metamorphic and igneous rock. In the valleys, the surface soils range from sandy alluvium to fine loams and silty clays with heavier subsoils. The principal vegetal cover in the mountain and foothill areas consists of chaparral, sage, grasses, and scattered deciduous trees. Sycamores, alders, cottonwoods and willows encroach upon the stream channels at lower elevations. Large segments of the valleys and foothills have been cleared of most native vegetation due to extensive development, especially the area downstream of Weir Canyon Road. The remaining valley areas are mainly covered with orchards and field crops.

Hydrometeorological Characteristics

2-09 In general, the Santa Ana River Basin has a mild climate with warm, dry summers and cool, wet winters. Both temperature and precipitation vary considerably with distance from the ocean, elevation, and topography. At the city of Corona, about 26 miles from the ocean and 710 feet above sea level, the average temperature is about 63 degrees F, with extremes of 22 degrees F and 118 degrees F recorded. At Squirrel Inn, located in the San Bernardino Mountains at an elevation of 5,700 feet NGVD, the average temperature is about 53 degrees F, with extremes of zero degrees F and 97 degrees F recorded. Precipitation characteristically occurs in the form of rainfall, although in the higher elevations some falls as snow. In general, the quantity of precipitation increases with elevation. The 91-year mean seasonal precipitation (pl. 7-11) for the basin, which averages about 20 inches, varies from 10 inches south of the city of Riverside to about 45 inches in the higher mountain areas. Nearly all precipitation occurs during the months of December through March. Rainless periods of several months during the summer are common.

Storm Types

2-10 Three types of storms produce precipitation in the Santa Ana River Basin: general winter storms, local storms, and general summer storms.

2-11 General winter storms usually occur from December through March. They originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific air masses and move eastward over the basin. These storms, which often last for several days, reflect orographic influences and are accompanied by widespread precipitation in the form of rain and, at higher elevations, some snow.

2-12 Local storms can occur at any time of the year, either during general storms or as isolated phenomena. Those occurring in the winter are generally associated with frontal systems. These storms cover comparatively small areas, but result in high-intensity precipitation for durations of up to 6 hours.

2-13 General summer storms in this area are usually associated with tropical cyclones and occur very infrequently. They are known to have occurred in the late summer and early fall months, but have not resulted in any major floods during the period of record.

Runoff Characteristics

2-14 Streamflow, which is perennial in the canyons of the Santa Ana River and in the headwaters of most of its tributaries, is generally ephemeral in most valley segments. Streamflow increases rapidly in response to effective precipitation. High-intensity precipitation, in combination with the effects of steep gradients and possible denudation by wildfire may result in intense sediment-laden floods, with some debris load in the form of shrubs and trees. Deposition of sediment occurs in the stream channels as they flow from the canyon mouths onto the lower-sloped valley floor surface. The urbanization taking place in the valley areas of the Santa Ana River Basin tends to make the basin more responsive to rainfall. Hence, the same rainfall occurring over an urbanized segment of the basin will result in higher peak discharges, with a shorter time to the peak and a greater volume than had it occurred over a natural basin without urbanization.

Existing Structures

WATERSHED ABOVE SEVEN OAKS DAM (UPPER SANTA ANA RIVER BASIN)

2-15 Big Bear Dam is the only existing structure which would affect floodflows in this watershed (pl. 7-6). Big Bear Lake is a water-conservation reservoir, owned by the Big Bear Municipal Water District. The lake has a drainage area of about 38 square miles and has a surcharge storage of about 8,600 acre-feet between the top of the conservation pool and the top of the dam.

STRUCTURES BETWEEN SANTA ANA RIVER BASIN TO PRADO DAM

2-16 Two major flood-control dams (pl. 7-6) are located in the Santa Ana River Basin. These structures, Prado Dam and San Antonio Dam, were built by the Corps of Engineers. Other existing flood control improvements, including those on Cucamonga, Deer, Lytle, and Cajon Creeks, have been constructed by the Corps of Engineers and local interests (pl. 7-6). These improvements include channelization, debris basins, storm drains, levees, stone and wire-mesh fencing, and stone walls along the banks of stream channels. The principal existing water conservation improvements are spreading grounds and reservoirs. The more than 100 water conservation and recreational reservoirs within the basin have storage capacities ranging in volume from less than 5 to about 182,000 acre-feet in the case of Lake Mathews. Although most of the existing water-conservation improvements affect the regimen of the lesser floodflows, major floodflows are not appreciably affected. Lake Elsinore, the terminus for the San Jacinto River, has considerable potential influence on flood runoff, especially if its water surface elevation is low at the beginning of a storm. Lake Elsinore has a dead storage capacity of about 130,000 acre-feet. When full, Lake Elsinore overflows into Temescal Wash, which joins the Santa Ana River near Prado Dam.

MILL CREEK

2-17 The only existing flood control structure in the Mill Creek drainage area is a levee system (pls. 7-3 and 7-6) comprised of levee embankments and masonry walls. The main levee structure is a 13,600-foot compacted earthfill embankment built by the Corps of Engineers in 1960. Local interests had previously built about 2,000 feet of masonry walls which tie into the upstream end of the Corps' levee, and about 2,400 feet of guide levees to control low flows. These structures are protected by rock and wire revetments. The lower 1,800 feet of the Corps' levee is ungrouted stone revetment, with the remaining upstream length being protected by grouted stone revetment.

OAK STREET DRAIN

2-18 Within the Oak Street Drain watershed, two debris basins have been constructed by RCFCWD (pl. 7-4). Mabey Canyon and Oak Street debris basins were completed in late 1973 and October 1979, respectively. Together, these basins control debris emanating from Kroonen, Hagador, Tin Mine, and Mabey Canyons. Mabey Canyon debris basin was designed to provide debris storage of 108 acre-feet with a spillway capable of passing 3,100 cubic feet per second (ft^3/s). Oak Street debris basin was designed to provide 253 acre-feet of debris storage with a spillway capable of passing 7,700 ft^3/s. Other structures affecting runoff are Mangular Border Drain (downstream of Mabey Canyon debris basin), and Main Street Drain. Main Street Drain discharges flow into Oak Street Drain approximately 1,500 feet upstream of the confluence with Temescal Wash. The existing Oak Street Drain channel from the debris basin to the confluence with Mangular Border Drain consists of steel rail and

wire mesh bank protection with a natural earth channel bottom. A concrete-lined channel extends from this confluence downstream to Railroad Street. The remaining reach downstream to Temescal Wash is a natural channel.

SANTIAGO CREEK

2-19 The Santiago Creek channel (pl. 7-6) has been improved over the years by local interests. During the 1930's, masonry walls were constructed from the Santa Ana Freeway through Hart Park. Within Hart Park, the channel bottom has been paved for use as a parking lot. Riprap was placed along the west bank upstream from Chapman Avenue for the protection of homes along the bank. Downstream from Prospect Avenue, concrete sideslope protection has been placed to protect homes that were damaged by the 1969 floods. On Handy Creek, a concrete channel runs from just downstream of Orange Park Boulevard to its confluence with Santiago Creek. Two large gravel pits (Blue Diamond and Bond Pits), downstream from Villa Park Dam, act as reservoirs for floodwaters (pl. 7-6). During minor floods, flows are completely contained within the pits, and never reach the downstream channel. However, during major floods, water will fill the pits and overflow to the downstream channel. Villa Park Dam, approximately 2 miles upstream of the Blue Diamond - Bond Pits, is a flood control facility with a capacity of 16,000 acre-feet, constructed by the Orange County Flood Control District (OCFCD) in 1963. Santiago Dam, upstream from Villa Park Dam, is a water supply reservoir constructed by the Irvine Company in 1933.

LOWER SANTA ANA RIVER BASIN FROM PRADO DAM TO THE PACIFIC OCEAN

2-20 Two major flood control dams are located in the Santa Ana River Basin below Prado Dam (pl. 7-6). Carbon Canyon Dam, located on Carbon Canyon Creek, was built by the Corps of Engineers in 1961. Villa Park Dam was completed by the Orange County Flood Control District in January 1963. Other existing flood control improvements have been constructed by local interests. These improvements include channelization, storm drains, levees, rip-rap and concrete side slope protection, and drop structures. The principal existing water conservation improvements are spreading grounds, recharge basins, and Irvine Lake (at Santiago Dam).

Recommended Project Elements

2-21 The Santa Ana River Project will consist of six major project elements (pl. 7-1); the construction of Seven Oaks Dam on the upper Santa Ana River; the raising of the existing Prado Dam by about 30 feet to provide greater flood control capability; improving 23 miles of channels and levees on the Lower Santa Ana River below Prado Dam; constructing a floodwall on top of the existing Mill Creek levees; channel improvements on the existing Oak Street Drain in the city of Corona; and developing flood control storage in the existing gravel pits and improving the existing channel on Santiago Creek. Other elements of

the project include; the management of the flood plain by local interests between Seven Oaks Dam and Prado Reservoir in accordance with guidelines of the Federal Emergency Management Agency, the acquisition of approximately 1,000 acres of flood plain in Santa Ana Canyon below Prado Dam for a natural floodway ranging in width from 1,000 to 3,000 feet, restructuring the Greenville-Banning Channel, Talbert Channel, and the 92 acre salt marsh restoration at the river mouth, and other recreational and mitigational features.

III. PRECIPITATION AND RUNOFF

Precipitation Gauges

3-01 Precipitation records are available for almost 500 rainfall stations in and near the Santa Ana River Basin (pl. 7-12 and table 7-1). The standard gauging station at San Bernardino County Hospital has the longest period of record, dating back to 1870. Automatic gauge records are available for many stations in the drainage basin. The Claremont-Pomona College station, with records dating back to 1927, has automatic gauge records covering the longest period of time.

Stream Gauges

3-02 Runoff records are available for about 65 stream gauging stations (pl. 7-13 and table 7-2) within the project drainage area. Many of the stations are on canals and diversion channels. The station at Santa Ana River near Mentone, where non-recording gauges were used from 1896 to 1917 and recording gauges from 1917 to the present, has the longest period of record for a stream gauging station on a natural stream in southern California. The San Antonio Creek station near Claremont, which has been in operation since 1901, used non-recording gauges up until 1917, and recording gauges from 1917 to the present. Ten stations have had recording gauges in operation since 1919, and several of these stations had non-recording gauges for a few years prior to that time. In common with the majority of stream discharge records in southern California, runoff records for the gauging stations during large floods are generally incomplete. This has been caused by the destruction of gauging stations during floods and by a lack of equipment and personnel necessary in making discharge measurements of high velocity flows. Few satisfactory hydrographs are available for the 1938 flood, the largest flood in the drainage area since gauging stations were established. During the Santa Ana investigation by the State of California, many stations were maintained during the 1927-28 season, but no important floods were recorded. Data on these stations are available in bulletin No. 19 of the California Department of Public Works.

Storms and Floods of Record

3-03 Although historical reference to flood conditions in the general region date back to about 1769, little information is available regarding the magnitude of floods occurring prior to 1850. Historical references indicate that (from 1769 to 1850) medium-to-large floods occurred in 1825, 1833, 1840, and 1850. Some available quantitative data indicates that, from 1850 to 1897, medium-to-large winter floods occurred in 1859, 1862, 1867, 1876, 1884, 1886, 1889, and 1894. Recorded data from 1897 to the present indicate that medium-to-large winter floods occurred in 1903, 1910, 1914, 1916, 1921, 1922, 1927, 1938, 1943, 1965, 1966, 1969, 1978, 1980, and 1983. Following the historical floods of the 1800s and early 1900s, considerable changes have occurred in the drainage basin. Runoff characteristics of the majority of the valley areas have been changed by urbanization and agriculture. The mountain areas have remained relatively unchanged, although several small reservoirs, detention dams, and debris basins have been constructed at the canyon mouths. In the event that a large, historical storm occurred under present-day conditions, mountain runoff would be similar to that incurred in the past since these small structures would have little effect on major floods on the mainstem of the Santa Ana River above Prado Dam. Valley runoff would be considerably higher in both peak and volume because of increase in impervious cover due to development and channelization of flows.

3-04 Little information is available pertaining to the storms which led to the great flood of 1862. No rainfall amounts are available for the area in or near the Santa Ana River Basin. Accounts of the time, however, tell of 18 straight days of rain, and a flood that "wrought great destruction and desolation", as described by settlers in the area. The storm of February 27-March 3, 1938, was one of the most severe general storms of record for southern California. Ground conditions were conducive to runoff due to saturated soil conditions resulting from greater than normal precipitation during the month preceding the storm. The heavy precipitation of the March 1-2 period, along with the low precipitation-loss rate, resulted in numerous peak discharges of record on the Santa Ana River. The storm of January 21-24, 1943 was the most severe of its kind on record in nearly every respect. Because of less saturated soil conditions, however, runoff produced by this storm was less than that produced by the storm of 1938. The storm of March 3-4, 1943, is described as a local thunderstorm that resulted in short-period precipitation of near record-breaking magnitude for the southern California coastal region. The storms of January 18-27, and February 22-25, 1969, brought extremely heavy precipitation to the southern California area. Because ground conditions were more conducive to runoff than during the January 1943 storm, each of the 1969 floods produced peak discharges greater than the January 1943 flood. The storms of February 5-11, and February 27-March 6, 1978, brought widespread moderate-to-heavy precipitation into southern California. Areas impacted by damaging rainfall extended from Santa Barbara County eastward to San Bernardino and Riverside Counties. The storms of February 1980 were similar to the 1978 storms, and again brought

widespread moderate-to-heavy precipitation into the area. Areas most affected included the southwestern San Fernando Valley and the San Jacinto - Lake Elsinore area. The storms and floods of February-March 1983 were the climax of a season of repeated moderate-to-heavy storms across southern California, resulting from the strongest El Niño phenomenon in many decades. Very heavy rains fell from Ventura County to San Bernardino and Riverside Counties and southward through Orange County. Additional information on the above storms and floods is given in the Review Report, Phase I General Design Memorandum, and the Phase I GDM Supplement.

IV. SYNTHESIS OF STANDARD PROJECT FLOOD

General

4-01 The standard project flood (SPF) represents the flood that would result from the most severe combination of meteorologic and hydrologic conditions considered reasonably characteristic of the geographical area. The SPF is normally larger than any past recorded flood in the area and would be exceeded in magnitude only on rare occasions. It thus constitutes a standard for design that would provide a high degree of flood protection. Estimates of the SPF were made in accordance with EM 1110-2-1411 (Standard Project Flood Determinations). The SPF determination was presented in detail in section H of the technical appendix of the 1975 Review Report.

Standard Project Storm

4-02 The standard project storm for the Santa Ana River Basin was determined by evaluating severe storms to determine the event that represents the most severe flood-producing rainfall, depth-area duration relationship and isohyetal pattern that is considered reasonably characteristic of the region. A general-storm was determined to govern for all points under consideration on the Santa Ana River, Mill Creek and Santiago Creek, and a local-storm for Oak Street Drain.

General Winter Type

4-03 The critical storm for the Santa Ana River, Mill Creek and Santiago Creek is based on the assumed occurrence of a storm equivalent in magnitude to that of January 21-24, 1943, in which maximum 24-hour precipitation (pl. 7-14) was transposed and centered critically over the area tributary to the basin concentration points.

Local Type

4-04 The 3-hour thunderstorm of March 1943 (pl. 7-15) proved to be the critical storm when centered over the tributary areas of the Lower Santa Ana River and Oak Street Drain.

Determination of Standard Project Flood

GENERAL

4-05 Standard project floods (SPF) were computed by determining the following: (a) unit-time precipitation for each subarea; (b) effective precipitation by subtraction of loss rates and by application of an imperviousness factor where applicable; (c) subarea surface-runoff hydrograph by application of subarea synthetic unit-hydrograph values to the effective unit period precipitation; (d) subarea total-runoff hydrograph by addition of base flow; and (e) total flood hydrograph by reservoir and channel routing, subtraction of percolation losses, and combining subarea hydrographs as required.

SEVEN OAKS DAM

4-06 The SPF peak discharge for the Seven Oaks Dam drainage area (pl. 7-2) was computed using pertinent subarea drainage characteristics (table 7-3), and by centering the January 1943 general standard project storm over the San Bernardino Mountains upstream of the damsite. The present and future SPF peak inflow (pl. 7-16) for this site is 82,000 ft^3/s with a 4-day volume of 110,500 acre-feet.

PRADO DAM

4-07 The computation of SPF for Prado Dam (pl. 7-1) is presented in the 1975 Review Report. The SPF at Prado Dam was produced by the general standard project storm centered over the San Bernardino and San Gabriel Mountains. The SPF inflow and outflow hydrographs for present and future "without project" conditions, (pls. 7-17 and 7-18, respectively) were computed using pertinent subarea drainage characteristics given in table 7-3.

MILL CREEK

4-08 The SPF hydrograph (pl. 7-19) and resultant peak discharge of 33,000 ft^3/s at the Mill Creek levees were produced by centering the general standard project storm over the Mill Creek drainage area (pl. 7-3 and table 7-3) in the San Bernardino Mountains, upstream of the existing levee location. A detailed analysis of the SPF determination is found in "Design Memorandum No. 1, Hydrology for Mill Creek Levees, U.S. Army Engineers District, Los Angeles, Corps of Engineers, June 1958".

OAK STREET DRAIN

4-09 The 3-hour local thunderstorm of 3-4 March 1943; the critical storm for Oak Street Drain (pl. 7-4), along with subarea drainage characteristics (table 7-4), was used to compute the present and future SPF "without project" hydrographs and discharges (pl. 7-20). Rainfall amounts and precipitation intensity patterns were taken, unaltered, from the report by the Hydrologic Engineering Center "Generalized Standard Project Rain Flood Criteria, Southern California Coastal Streams," dated March 1967.

SANTIAGO CREEK

4-10 The SPF inflow and outflow hydrographs and SPF peak discharges for concentration points on Santiago Creek (pl. 7-5) were produced by centering the general standard project storm over the Santiago Creek drainage area (table 7-5). The general storm, critically centered over the watershed, produced an SPF future hydrograph (pl. 7-21) and peak discharge of 29,000 ft^3/s, and a 4-day volume of 44,790 acre feet at Villa Park Dam.

LOWER SANTA ANA RIVER BASIN

4-11 Design flood peak discharges on the Santa Ana River below Prado Dam (table 7-6) were produced by the general storm, critically centered above Prado Dam with contemporaneous rainfall from the same general storm falling on the drainage area below Prado Dam (pl. 7-7 through 7-10 and tables 7-7 and 7-8). The computation of SPF for the Santa Ana River above Prado Dam was presented in the 1975 Review Report. The SPF greatly exceeds the capacity of the existing Prado Dam, and spillway discharge from Prado Reservoir exceeds the capacity of the downstream channel.

V. FREQUENCY ANALYSIS AND DESIGN DISCHARGES

General

5-01 Development of the discharge-frequency curves, volume-frequency curves, design discharges, reservoir operations, filling-frequency curves, and elevation-duration-frequency curves, where applicable, are outlined in the following paragraphs. The discharge-frequency and volume-frequency curves for the mainstem Santa Ana River and Santiago Creek are a combination of analytical and graphical analysis thus precluding the use of the expected probability adjustment. Tables 7-9, 7-10, and 7-11 show present and future Santa Ana River Mainstem discharge-frequency and SPF values. Design floods for each project element include: (1) Seven Oaks Dam (NED), 350-year event; (2) between Seven Oaks Dam and Prado Dam, 100-year flood plain management; (3) Santiago Creek, 100-year event; (4) Prado Dam, 190-year event; (5) lower Santa Ana River, 190-year event; and (6) Oak Street Drain, 100-year event.

Seven Oaks Dam

DISCHARGE-FREQUENCY WITHOUT PROJECT

5-02 The discharge-frequency relationships for Seven Oaks Dam (pl. 7-22) were derived from data collected at the stream gauge "Santa Ana River near Mentone", which is located about 1 mile downstream of the damsite. No changes were made to the 1975 Review Report discharge-frequency curve which was presented without the expected probability adjustment. The additional years of record were examined and judged to have no significant impact on the relationships developed in the 1975 Review Report. Present and future condition curves are the same, since increases in urbanization would be negligible throughout the project life. Additional detailed information regarding the derivation of this curve is found in the 1975 Review Report.

VOLUME-FREQUENCY

5-03 The volume-frequency curves (pl. 7-22) for both present and future conditions adopted for Seven Oaks Dam were derived in the 1975 Review Report for the stream gauge "Santa Ana River near Mentone". Additional years of record were examined and judged to have no significant impact on the relationships developed in the 1975 Review Report.

DESIGN DISCHARGES

5-04 The future SPF hydrograph (pl. 7-23), with a peak inflow of 82,000 ft^3/s and a 4-day volume of 110,500 acre-feet fills the reservoir to a maximum water surface elevation of 2574.93 feet NGVD or 5.07 feet below spillway crest. The initial water surface elevation for the SPF routing is elevation 2300 feet (top of debris pool) for future conditions. The appropriateness of this elevation is manifested in the water control plan for Seven Oaks Dam. The water control plan requires the release of floodflows as soon as possible to draw down the reservoir pool to the top of the debris pool in preparation for the next flood event. The operation of Seven Oaks Dam is discussed in paragraph 5-06. The estimated time to empty the reservoir after an SPF is about 14 days, assuming no additional storm inflow. The SPF is estimated to be a 333-year frequency event by comparing the 1-, 2-, 3-, and 5-day SPF volumes to the extended Seven Oaks Dam volume-frequency curves. (Frequency of SPF is based on volume, not peak discharge.)

5-05 The reservoir design flood (RDF) hydrograph (pl. 7-24), which results in a spillway crest water surface elevation of 2580 feet NGVD, was determined from National Economic Development (NED) plan considerations, such that the peak discharge is 85,000 ft^3/s and the 4-day critical volume is 115,000 acre-feet (pl. 7-25). The initial water surface elevation for the routing is identical to that of the SPF routing. The duration of critical volume is that which generated the peak discharge and water surface elevation. The reservoir operation is the same as for the SPF. The estimated time to empty the reservoir after an RDF is about 15 days, assuming no additional storm inflow. The RDF is estimated to be a 350-year event by comparing the 1-, 2-, 3-, and 5-day RDF volumes to the extended Seven Oaks Dam volume-frequency curves. (Frequency of RDF is based on volume, not peak discharge.)

RESERVOIR OPERATION

5-06 The operation of Seven Oaks Dam for present and future conditions (Tables 7-12 and 7-13) during major flood events is based on flood conditions downstream at Prado Dam. Initially, any inflow occurring from November through May is stored in the reservoir for the purpose of building a debris pool. During this period, when the water surface elevation is at the top of the debris pool (2200 feet NGVD for present conditions and 2300 feet NGVD for future conditions), the debris pool requirement is met, and scheduled releases are implemented. The debris pool (no matter what the date at which it is attained), is to be maintained until June. In June, 10 ft^3/s over the rate of inflow

(if any) to the reservoir is released from the debris pool for all water surface elevations up to the top of the debris pool. During July and August, drainage of the debris pool is accelerated by increasing the release rate to 20 ft^3/s over the rate of inflow (if any) to the reservoir. The reservoir will normally be dry in September and until the next year's debris pool is formed. During storm and flood periods, the operation plan at Seven Oaks Dam requires maintaining outflow equal to inflow up to a maximum discharge rate of 500 ft^3/s, until such time that the flood threat at Prado Dam has passed. At the initiation of falling water surface elevation at Prado Dam, a maximum discharge of up to 7000 ft^3/s is released, in order to lower the reservoir to the debris pool level. A deviation to the rising pool schedule of operation occurs between the upper and lower elevations of the trash racks at elevations 2299 feet NGVD and 2264 feet NGVD, respectively. Maximum discharge during this range of pool elevations is limited to 50 ft^3/s to prevent floating debris from accumulating on the trash structure. In tables 7-12 and 7-13, the last column indicates the maximum release that could be made with all gates fully open (misoperation). The outlet works were sized to pass a slightly larger discharge to provide flexibility and a factor of safety for the reservoir operation plan.

DISCHARGE-FREQUENCY WITH PROJECT

5-07 The present and future inflow discharge-frequency curves at Seven Oaks Dam (pls. 7-26 and 7-27, respectively) for "with project" conditions, remain unchanged from the "without project" curves since increased urbanization to the watershed is determined to be negligible. The present and future outflow discharge-frequency curves at Seven Oaks Dam (pls. 7-26 and 7-27, respectively) for with project conditions were developed by routing 2-year through 500-year frequency balanced hydrographs, derived from the volume-frequency curves for the dam, using the operation schedules given in tables 7-12 and 7-13, respectively. No difference exists between the present and future balanced hydrographs since no significant urbanization is planned for the watershed upstream of the damsite, consequently, the reduction of storage capacity due to future reservoir sedimentation accounts for the variations between present and future condition curves. From the routings, peak discharges for each frequency event were identified and plotted, with a smooth curve drawn through the points.

ELEVATION-DURATION-FREQUENCY CURVES

5-08 The development of elevation-duration-frequency curves for present and future conditions (pls. 7-28 and 7-29, respectively), was accomplished by routing recorded daily values for the period 1915 to 1985 through Seven Oaks Dam, using the falling pool schedule (tables 7-12 and 7-13, respectively). During periods in which large floods occurred (1916, 1918, 1937, 1938, 1966, 1969, 1979, 1980, and 1983) separate runs were made using both the rising and falling schedules (tables 7-12 and 7-13). The simulated daily water surface elevations were ranked by magnitude for durations of 1 to 365 days for each year.

Each duration was then ranked by magnitude for the period of record, and plotted using median plotting positions. For example, the largest event for the period of record represents an approximately 100-year event and the median event represents an approximately 2-year event. Smooth best-fit curves were drawn through the plotted points. These elevation-duration frequency curves were developed for both present and future conditions, i.e., the daily flows were routed through Seven Oaks Dam with respect to no sediment (present) and 100-year sediment (future) accumulation.

FILLING-FREQUENCY

5-09 The present and future Seven Oaks Dam filling-frequency curves (pl. 7-30) were developed by first plotting the maximum 1-day water surface elevations from the elevation-duration curves pertaining to events of 2-year to 100-year frequency. Water surface elevations for less frequent events were determined by routing greater than 100-year balanced hydrographs, developed from volume-frequency curves, through the present and future Seven Oaks Dam models. Maximum water surface elevations were plotted corresponding to the indicated frequency. Smooth curves were drawn through the plotted points.

Prado Dam

DISCHARGE-FREQUENCY WITHOUT PROJECT

5-10 No changes were made to the present and future inflow discharge-frequency curves for Prado Dam (pls. 7-31 and 7-32, respectively) from those published in the 1975 Review Report. Additional years of record were examined and judged to have no significant impact on the relationships developed in the 1975 Review Report. Derivation of these curves is found in the Review Report. The "without project" outflow curves for present and future conditions (pls. 7-31 and 7-32, respectively), were developed by routing 2-year through 200-year frequency "without project" balanced hydrographs through existing Prado Dam using the historical operation schedule. The historical operation derivation is described in paragraphs 5-17 through 5-20, which discuss the analysis of elevation-duration-frequency curves at Prado Dam.

VOLUME-FREQUENCY

5-11 The volume-frequency curves for Prado Dam (pls. 7-33 and 7-34, respectively) remain unchanged from those in the 1975 Review Report, for both present and future, "without project" conditions. These curves are based mainly on volume-frequency curves (pl. 7-35) derived from stream gauge data for Santa Ana River at Riverside Narrows. The development of the Prado Dam curves and the Riverside Narrows curves is discussed in the 1975 Review Report. Additional years of record for the above curves were examined and judged to have no significant impact on the

relationships developed in the Review Report. The "with-project", present and future volume-frequency curves for Prado Dam (pls. 7-36 and 7-37, respectively) were developed by adjusting the "without-project" volume-frequency curves for the effect of Seven Oaks Dam. The "without-project" SPF basin model, for present and future conditions, was calibrated to produce SPF and various n-year peak discharges and volumes. Subsequently, Seven Oaks Dam was added to the model. The SPF and n-year peak discharges and volumes reflecting the influence of Seven Oaks Dam were computed and plotted.

DESIGN DISCHARGES

5-12 The RDF (pl. 7-38), which results in a spillway crest water surface elevation of 563 feet NGVD, occurs by routing 92% of the SPF future condition hydrograph through the enlarged Prado Dam. The peak discharge for the RDF is 254,000 ft^3/s and the duration of critical volume (about 380,000 acre-feet) is about 2 days (pl. 7-25). The initial water surface elevation for the RDF routing is elevation 490 feet (top of debris pool) for future conditions. The appropriateness of this elevation is manifested in the water control plan for Prado Dam. The water control plan requires the release of floodflows as soon as possible to draw down the reservoir pool to the top of the debris pool in preparation for the next flood event. The frequency of the event that produces this volume was determined to be approximately 190-year by comparison of durations and volumes from the RDF hydrograph with the Prado Dam, "with project", volume-frequency curves. (Frequency of RDF is based on volume, not peak discharge.)

5-13 The recommended Prado Dam future SPF peak inflow is 275,500 ft^3/s and the maximum outflow is 30,000 ft^3/s (pl. 7-39). The critical 2-day volume is about 410,000 acre-feet. The frequency of the event which produces this volume is about a 200-year event, determined in the same manner as the RDF frequency. Outflow of 30,000 ft^3/s between elevations 563 and 566 feet NGVD is a combination of spillway flow and controlled outlet discharge. The initial water surface elevation for the SPF routing is the same as for the RDF routing (top of the debris pool). In generating the SPF inflow for the RDF into Prado Dam, the impacts at the dam from the proposed Lake Elsinore outlet channel improvement were considered. The improvement to the existing channel will consist of 2.5 miles of an unlined, trapezoidal channel with bottom widths varying from 30 feet to 70 feet. The results of a study in the 1983 Lake Elsinore Review Report, evaluating the impacts on Prado Dam and Temescal Wash from a 100-foot wide outlet channel, show the effect of the channel on the Prado Dam SPF water surface elevation is negligible because of the relative timing of the Temescal Wash hydrograph. Consequently, the impacts from the smaller channel are also judged to be negligible.

RESERVOIR OPERATION

5-14 New present and future operation schedules were developed for the recommended Prado Dam (tables 7-14 and 7-15, respectively). The operational debris pool is at elevation 490 feet NGVD. The top elevation of the debris pool is normally established to provide sufficient water depth to fully submerge the outlet gates and to prevent

vortex action from drawing floating debris into the gate openings. For water surface elevations lower than elevation 490 feet NGVD, releases are normally made to accommodate downstream ground water recharge capabilities. For water surface elevations higher than elevation 490 feet NGVD, releases are a function of reservoir water surface elevations only. The release values are considered average values since times will occur when actual releases will be higher or lower depending on particular upstream and downstream factors at that time. These factors include time of flood season, rain and runoff, activities in and condition of the downstream channel, rain and runoff in the area downstream of Prado Dam, and current reservoir status in terms of inflow, outflow, and storage. Generally, during the winter flood season (November through March), the water surface elevation within the reservoir is lowered according to schedule after the occurrence of large inflows to insure adequate flood storage for future inflows.

DISCHARGE-FREQUENCY WITH PROJECT

5-15 The present and future inflow discharge-frequency curves for "with project" conditions at Prado Dam (pls. 7-31 and 7-32, respectively) were developed by reducing the SPF peak discharges from the Santa Ana River basin model for present and future conditions. The SPF was reduced by the ratios of n-year discharges to SPF discharges from the "without project" curves, and multiplying them by the present and future "with project" SPF discharges of 230,000 ft^3/s and 275,500 ft^3/s, respectively. The present and future outflow discharge-frequency curves for "with project" conditions at Prado Dam (pls. 7-31 and 7-32, respectively) were developed by routing 2-year through 200-year frequency balanced hydrographs, derived from the volume-frequency curves for the dam, using the operation schedules presented in tables 7-14 and 7-15. The difference between the present and future outflow curves is an accounting, in the various future flood routings, for increased urbanization and future reservoir sedimentation. From these routings, peak discharges for each frequency event were identified and plotted, and a smooth curve was drawn through the points.

ELEVATION-DURATION-FREQUENCY CURVES

5-16 The Santa Ana River Project study required a definition of baseline conditions at Prado Dam under existing conditions and a comparable definition under project conditions in order to determine impacts of the project. These impacts are mainly environmental in nature and do not generally involve design considerations.

5-17 The first objective was to establish elevation-duration-frequency curves for the existing Prado Dam based on historical operation of the dam from 1969 through 1987. The year 1969 is significant because, in May 1969, the second ungated outlet was closed and an operational debris

pool was established at elevation 490 feet NGVD. Daily values of reservoir water surface elevation and daily-average-release values were tabulated. Reservoir water surface elevations versus outflow discharge values were plotted, and a regression line fitted to the values. All values were treated equally and no attempt was made to sort out reasons and situations that influenced a particular release. The regression line thus established a relationship between reservoir water surface elevation and reservoir outflow that integrated all the operational constraints and objectives.

5-18 The daily value inflows for water years 1970 through 1987 were routed through Prado Dam using the regression relation to define the reservoir operation. This step allowed a comparison of the regression release schedule and the actual recorded water surface elevations. The first attempt resulted in an underestimation of water surface elevations for below-average-runoff years and an overestimation of water surface elevations for above-average-runoff years.

5-19 The annual (regression) schedule was then adjusted by judgement and by trial and error in order to best reproduce the recorded water surface elevations. The goal was to match the total number of days above elevation 490 feet, elevation 500 feet, and the maximum water surface elevations for above-average-runoff years. Using this approach, the total number of days above elevation 490 feet and elevation 500 feet were reproduced within 13 percent and 19 percent, respectively. Naturally, in any particular year the match between the actual reservoir routing and the hypothetical routing (using the adjusted regression release schedule) ranged from good to poor depending on the circumstances affecting reservoir operation in that year. In general, water surface elevations for low runoff years were underestimated and high runoff years were overestimated.

5-20 The period from 1970 to 1987 contains some years of very high runoff and some years of very low runoff. In order to establish more reliable elevation-duration-frequency relationships, a longer period of record was used. The inflow data for Prado Dam from 1950-1987 was used in the simulation model with the adjusted regression release schedule (henceforth called the average release schedule) to determine elevation-duration-frequency relationships. This period (1950-1987) is representative of the long term average, in that the departure from the long term mean for rainfall and runoff based on precipitation and streamflow gauges from undeveloped areas in the Santa Ana River watershed is small. Many changes occurred in the watershed during this period in terms of urbanization and treated effluent discharge to the river, thus making the runoff record non-homogeneous. However, the availability of certain information allowed adjustment of the record to a common base. Wastewater effluent values were taken from the Santa Ana River annual Watermaster Reports. The difference between the 1987 value and the value for each year in the period 1950 to 1986 was then added to that years' daily values to bring it to 1987 conditions. A similar analysis was made to adjust the historical inflow for the period of record (1950-1986) to the year 2030, which represents future conditions. A direct

runoff adjustment was made based on annual urbanization increases and corresponding annual percent impervious cover increases. A relationship between 1-day discharges and frequencies for various percent impervious cover relationships was developed, i.e., discharge-frequency curves were developed relating impervious cover to some year within the period of record. Using 18 percent impervious cover for 1975 (based on the 1975 Review Report) and assuming 6 percent impervious cover for 1950, the remaining record was estimated from linear interpolation of annual urbanization increases. Each identified direct runoff value was adjusted as shown in the example on plate 7-40 to normalize the record to 1987 conditions. This adjusted Prado Dam inflow record, using the average release schedule, was then routed through Prado Dam. The resulting simulated daily water surface elevations were ranked by magnitude for durations of 1 to 365 days and plotted using median plotting positions. For example, the largest event for the 38 years of record represents an approximately 50-year event and the median event represents an approximately 2-year event.

5-21 As stated previously, the simulation using an average-release schedule tends to underestimate the water surface elevation for low-runoff years. In order to adjust for this, the total annual adjusted runoff volume for the years 1950 - 1987 was ranked by magnitude and assigned a frequency using median plotting positions. The annual runoff volumes for the years 1970 to 1987 (recall that the present reservoir operation was established in May 1969) were then assigned a frequency using the larger representative period (1950 - 1987). The number of days above elevation 490 feet and above elevation 500 feet actually recorded for these years were used along with the results of the simulation runs to smooth and adjust the final elevation-duration-frequency curves. The resulting curves (pl. 7-41), provide the best estimate of elevation-duration-frequency relationships for the existing Prado Dam based on the historical operation for the last 18 years.

5-22 Elevation-duration-frequency curves (pl. 7-42) were also developed for the existing Prado Dam under future conditions. Many changes will occur in the future that will impact on the operation of Prado Dam. These include increased runoff due to urbanization, sediment deposition within the reservoir, either increased or possibly decreased treated effluent discharge, increased downstream recharge capability, increased channel capacity, changes within the Santa Ana Canyon, improvements in the Santa Ana River downstream channel, changes in upstream reservoir usage, etc. The sum total of all these changes will be somewhat compensated for by reservoir operation, but the elevation-duration-frequency relationships will be higher overall (i.e., maintenance of higher water surface elevations for longer durations) due mainly to sediment deposition. Elevation-duration-frequency curves for existing Prado Dam under future conditions were developed from a combination of simulation runs and comparison with present condition curves. The Prado Dam inflow record adjusted for future conditions was routed through Prado Dam using the average release schedule. The resulting simulated daily water surface elevations were ranked and plotted as for present conditions. The simulation results were used to establish the short

duration and long duration values. The intermediate duration values were adjusted to be consistent with, but slightly higher than the present condition curves.

5-23 Present and future elevation-duration-frequency curves for the recommended Prado Dam (pls. 7-43 and 7-44, respectively) were determined from simulation runs as were done for the existing Prado Dam, except the new Phase II release schedule was substituted for the average release schedule. The results of the simulation runs were ranked and plotted as indicated earlier.

FILLING-FREQUENCY

5-24 The present and future, "with" and "without project" filling-frequency curves for Prado Dam (pl. 7-45) were developed in a way similar to that used in the construction of the Seven Oaks Dam curves. Maximum 1-day water surface elevations from the Prado Dam elevation-duration-frequency curves for 2-year through 50-year were plotted. Balanced hydrographs for events of greater than 50-year frequency were run through the present and future models. The maximum water surface elevations for each corresponding frequency event were plotted and smooth curves drawn through the plotted points.

Santa Ana River Mainstem Between Seven Oaks Dam and Prado Dam

DISCHARGE-FREQUENCY WITHOUT PROJECT

5-25 No changes were made to the present and future, "without project" discharge-frequency curves for Riverside Narrows and E Street (pls 7-46, 7-47, 7-48, and 7-49, respectively) from those curves published in the 1975 Review Report. Derivation of these curves is found in the Review Report. The present and future, "without project" discharge-frequency curves for points downstream of City Creek and Mill Creek (pls. 7-50, 7-51, 7-52, and 7-53, respectively) were derived by adjusting the Santa Ana River near Mentone discharge-frequency curves for each location. The Santa Ana River near Mentone curves were used in lieu of the Mill Creek curve since the peak discharges for the locations downstream of City Creek and Mill Creek are a direct result of runoff from the upper Santa Ana River watershed. Hence, the discharge-frequency curves for locations downstream of City Creek and Mill Creek adopt the same general curve slope as the Santa Ana River near Mentone curves (pl. 7-22). SPF peak discharges for each location were computed using the Santa Ana River basin model. The resulting SPF discharges of 115,000 and 112,000 ft^3/s, for downstream of City Creek and Mill Creek, respectively, were plotted at the 180-year frequency, identical to the frequency of SPF at the Mentone gauge site. Using the SPF as anchor points, curves were drawn for each location parallel to the Mentone gauge curves. Present and future, "without project", discharge-frequency curves for these two locations are determined to be unchanged since increases in urbanization will be negligible.

5-26 Analytical discharge-frequency curves for City Creek and Plunge Creek (pls. 7-54 and 7-55, respectively) were drawn from data collected at the City Creek near Highland, California (sta. 11055800), and the Plunge Creek near East Highland, California (sta. 11054000) gauges (tables 7-16 and 7-17, respectively). Each curve was drawn in accordance with the Water Resources Council Bulletin 17B "Guidelines for Determining Flood Flow Frequency". The City Creek gauge has a period of record of 66 years. The Plunge Creek gauge has a period of record of 67 years.

DESIGN DISCHARGES

5-27 No flood control structures are proposed for the reach between Seven Oaks and Prado Dams. Flood control measures are relegated to floodplain management, thus requiring the determination of 100-year peak discharges at various locations in the reach between Seven Oaks Damsite and Prado Dam (pl. 7-25).

DISCHARGE-FREQUENCY WITH PROJECT

5-28 Present and future, "with project" discharge-frequency curves for Riverside Narrows and E Street (pls. 7-46 through 7-49, respectively) were developed in similar fashion to that of the Prado Dam "with project" discharge-frequency curves. Present and future "with project" SPF discharges were computed from the model, n-year to SPF ratios from the "without project" curves were computed and multiplied by the "with project" SPF discharges, the resulting n-year discharges were plotted, and curves were drawn. The present and future "with project" discharge-frequency curves for a location downstream of City Creek (pls. 7-50 and 7-51, respectively) were developed by taking n-year frequency discharges from the Mill Creek discharge-frequency curve and adding corresponding n-year frequency discharges from Seven Oaks Dam and from curves at Plunge Creek and City Creek. The relative timing of the peaks on Plunge Creek and City Creek were assumed to match that of the peak contributed by Mill Creek. The resulting total n-year frequency discharges were plotted and smooth curves drawn through the points. The present and future "with project" discharge-frequency curves for a location downstream of Mill Creek (pls. 7-52 and 7-53, respectively) were computed by taking the n-year discharges from the Mill Creek discharge-frequency curve, adding the corresponding n-year discharge from Seven Oaks Dam, and plotting the various n-year totals.

Mill Creek

DISCHARGE-FREQUENCY

5-29 The "Mill Creek near Yucaipa, CA" stream gauge was used to develop the discharge-frequency curve for Mill Creek (pl. 7-56). This gauge has a period of record extending from 1920 to 1986. An analytical discharge-frequency curve was drawn according to the Water Resources Council Bulletin 17B "Guidelines for Determining Flood Flow Frequency" (table 7-18) from discharge values for the period of record extending from 1920

to 1986, including an adjustment for an incomplete record. An adopted discharge-frequency curve at the levee location (pl. 7-56) was developed by adjusting the gauge curve downward to account for the attenuation of large observed flood events between the gauge site and the levee.

DESIGN DISCHARGES

5-30 The present and future, "with" and "without project" Mill Creek SPF peak discharge (pl. 7-19), is 33,000 ft^3/s, which is an approximately 200-year frequency flood event.

Oak Street Drain

DISCHARGE-FREQUENCY WITHOUT PROJECT

5-31 Present conditions, "without project" discharge-frequency curves for Oak Street Drain at the canyon mouth and Riverside Freeway (pl. 7-57) were developed in the 1975 Review Report. The discharge-frequency analysis performed for the Review Report was a regionalization, which yielded a graphical relationship of mean annual peak discharge per square mile vs. drainage area, as well as an average standard deviation and skew coefficient. The incorporation of additional recorded flow data obtained since the analysis for the 1975 Review Report was performed, did not significantly alter the regionally determined statistical relationships. Hence, relationships given in the Review Report are representative of prevailing conditions.

DESIGN DISCHARGES

5-32 The recommended plan for Oak Street Drain is to construct a channel providing 100-year flood protection in lieu of previous plans for SPF protection. The 100-year design flood peak discharges for concentration points along Oak Street Drain (pl. 7-58 and table 7-19) were derived by reducing SPF subarea hydrographs by the ratio of 100-year peak discharge to SPF peak discharge (0.65 for mountains and 0.55 for valley subareas) based on "without project" discharge-frequency curves. The 100-year design flood peak discharges for each location were determined by routing the individual subarea hydrographs along Oak Street Drain to Temescal Wash.

Santiago Creek

DISCHARGE-FREQUENCY AND VOLUME-FREQUENCY WITHOUT PROJECT

5-33 No changes were made to the peak or volume discharge-frequency curves for Santiago Creek at Villa Park Dam (pl. 7-59) from those given in the 1980 Phase I GDM. Additional years of record were examined and judged to have no significant impact on the relationships developed in the 1980 Phase I GDM. Derivation of the curves is found in the Phase I GDM. Annual maximum runoff values (table 7-20) for peak, 1-day, 2-day, and 3-day durations were used in the analysis.

5-34 An updated (Phase I GDM) analytical peak discharge-frequency curve (pl. 7-60) and statistics (table 7-21) for the Handy Creek stream gauge were developed according to the Water Resources Council (WRC) Bulletin 17B "Guidelines for Determining Flood Flow Frequency". Peak discharges for the period of record (1938-1985) are tabulated in "Hydrologic Data Reports" prepared by the Orange County Environmental Management Agency (OCEMA), which also operates and maintains the gauge. A generalized skew of -0.20 was adopted, based on previous reports.

DESIGN DISCHARGES

5-35 The recommended plan for Santiago Creek provides protection from the 100-year design flood (table 7-22 and pl. 7-61) for the residents of the Santiago Creek flood plain. The recommended improvements include constructing flood control gates at the outlet of Santiago Creek Reservoir (gravel pits) and constructing downstream channel improvements capable of passing the 100-year design discharge of 5,000 ft^3/s. The 100-year subarea hydrographs downstream from Villa Park Dam were derived from SPF hydrographs reduced by the ratio of 100-year peak discharges to SPF peak discharges. The ratio (0.58) used for all subareas except Handy Creek was computed from the frequency curve for Villa Park Dam (pl. 7-59). The ratio (0.57) for the Handy Creek drainage basin was computed from the frequency curve for Handy Creek (pl. 7-60). The 100-year inflow hydrographs at Santiago Dam and Villa Park Dam were developed from the volume-frequency curves at Villa Park Dam (pl. 7-59) using the balanced hydrograph method. The Villa Park Dam inflow balanced hydrograph was reconstituted by proportioning the runoff to subareas A and B (pl. 7-5), approximately by the ratio of the drainage areas. The hydrographs were patterned after the February 1969 flood hydrographs. The 100-year design discharges along Santiago Creek were generated by routing the 100-year inflow through Santiago Dam, with a starting water surface elevation at spillway crest elevation of 790 feet NGVD (pl. 7-62), then routed downstream to Villa Park Dam. The resulting inflow at Villa Park Dam was routed through the dam to Santiago Creek Reservoir, and combined with downstream contemporaneous runoff. The operation plan at Villa Park Dam consisted of a maximum controlled release of 3,500 ft^3/s and subsequent uncontrolled spillway flow for a total peak outflow of 5,700 ft^3/s (pl. 7-63). Inflow to Santiago Creek Reservoir was routed through the reservoir using an operation plan which maintained outflow equal to inflow up to a maximum release rate of 3,500 ft^3/s. Santiago Creek Reservoir stores the volume of uncontrolled spillway flow from Villa Park Dam in addition to contemporaneous runoff exceeding 3,500 ft^3/s (pl. 7-64). Additional contemporaneous runoff from the area downstream from Santiago Creek Reservoir was added to the outflow, resulting in a peak discharge of 5,000 ft^3/s at the Santa Ana River (pl. 7-61).

OPERATION SCHEDULE FOR SANTIAGO CREEK RESERVOIR (GRAVEL PITS), INCLUDING SANTIAGO DAM (IRVINE LAKE) AND VILLA PARK DAM

5-36 Santiago Creek Reservoir will possess a flood control storage allocation of 4,620 acre-feet between elevations 274 feet NGVD and 298 feet NGVD. A portion of the storage allocation above 274 feet may be used for water conservation purposes, dependent on the season. The

amount of storage above elevation 274 feet NGVD reserved for flood control purposes will also vary with the time of the year. Storage below elevation 274 feet NGVD will be used for water conservation and sediment storage only. Santiago Creek Reservoir flood control storage will be used to control discharge in the segment of Santiago Creek extending from the reservoir, downstream to the confluence with the Santa Ana River. Outflow from Santiago Creek Reservoir, combined with runoff from the drainage area downstream will not exceed the design discharge of 5,000 ft^3/s at the mouth of Santiago Creek. As previously stated, the design water control plan for flood control purposes for Santiago Creek Reservoir (table 7-23) varies with respect to the season, i.e., flood or non-flood season. The water surface elevations at Santiago and Villa Park Dams, upstream of the recommended Santiago Creek Reservoir, and the time of year during which storage is taking place, will be used to determine the starting elevation of flood control storage. The corresponding starting elevation of flood control storage for Villa Park Dam is specified by the Orange County Environmental Management Agency (OCEMA) in the "Villa Park Dam Operation Manual" dated 3 July 1985. The lowest flood control storage elevation for Santiago Creek Reservoir is 274 feet NGVD. When elevation 274 feet NGVD is reached, during periods in which the water surface elevation in the reservoir is rising, the outlet works are operated so that outflow is as specified in paragraphs 5-36 and 5-37. Following the flood peak, during falling water surface elevations, the maximum scheduled outflow (table 7-24) is maintained until the bottom of the flood control storage pool is reached.

5-37 The design water control plan for flood control purposes for Santiago Creek Reservoir during December through March (table 7-23) is set to maintain outflow from flood control storage equal to inflow up to a maximum of 3,500 ft^3/s. For the general storm design flood, the 100-year contemporaneous runoff from the area downstream of the reservoir, added to the 3,500 ft^3/s outflow from the reservoir, results in a peak discharge of 5,000 ft^3/s at the mouth of Santiago Creek. Maximum controlled outflow from upstream Villa Park Dam must be no greater than 3,500 ft^3/s in order for the water control plan to be able to control the 100-year flood.

5-38 The design water control plan for flood control for Santiago Creek Reservoir during April through November (table 7-23) is set to maintain outflow from flood control storage equal to outflow from Villa Park Dam up to a maximum of 3,500 ft^3/s. For the 100-year flood generated by a local storm, the runoff from the area downstream of Santiago Creek Reservoir could result in a peak discharge of 5,000 ft^3/s at the mouth of Santiago Creek without any outflow from Santiago Creek Reservoir. Therefore, in order for this water control plan to be able to control the 100-year flood generated by a local storm, there must be adequate flood control storage space available to capture the runoff from the area between Villa Park Dam and Santiago Creek Reservoir, with no outflow from Villa Park Dam.

5-39 The recommended Santiago Creek Reservoir outlet works will be operated by OCEMA. OCEMA will be responsible for operating the outlet gates whenever water control operations are necessary. Gate operations will be in accordance with instructions provided by the Los Angeles District Corps of Engineers.

Lower Santa Ana River

DISCHARGE-FREQUENCY WITHOUT PROJECT

5-40 Peak discharge-frequency curves for present and future, "without project" conditions, were developed for two locations along the Lower Santa Ana River: (1) at Imperial Highway and (2) at Santa Ana (pl. 7-65 through 7-68). The curves of Imperial Highway (pls. 7-65 and 7-66) were drawn in two parts. The upper portion of the curve was based on discharges developed in the Review Report. The lower portion of the curve was developed from two components: (1) n-year discharges from the Prado Dam outflow discharge-frequency curves and (2) the discharge contributed by the subarea downstream of Prado Dam. The future, "without project" conditions discharge-frequency curve of Santa Ana (pl. 7-68) was developed in a similar manner except local runoff from subareas downstream of Prado Dam to the Pacific Ocean was added to the n-year discharges from Prado Dam outflow curves. The present, "without project" discharge-frequency curve at Santa Ana (pl. 7-67) was also developed in two parts. The upper portion of the curve was drawn from data listed in the Review Report. The lower portion of the curve was drawn from a graphical analysis of historical gauge data recorded at the USGS gauge "Santa Ana River at Santa Ana." (Discharges were plotted according to median plotting positions and a smooth curve was drawn through the points.)

DESIGN DISCHARGES

5-41 The design flood peak discharges for future conditions (pl. 7-25 and table 7-6) on the Santa Ana River below Prado Dam were produced by critically centering a general storm above Prado Dam with contemporaneous rainfall from the same general storm falling on the drainage area below Prado Dam. This storm resulted in a computed outflow discharge of 30,000 ft^3/s from Prado Dam, which was routed downstream and combined with contemporaneous flow at each location to determine the design flood peak discharges.

DISCHARGE-FREQUENCY WITH PROJECT

5-42 Peak discharge-frequency curves for present and future "with project" conditions at Imperial Highway and Santa Ana (pls. 7-65 through 7-68) were developed in the same manner (except for the method used for present conditions at Santa Ana) as the "without project" curves. The "with project" analysis required the use of present and future outflow discharge-frequency curves at Prado Dam developed from the 2-year through 200-year "with project" inflow balanced hydrographs being routed through the recommended Prado Dam.

VI. SYNTHESIS OF PROBABLE MAXIMUM FLOOD

General

6-01 The probable maximum flood (PMF) is defined as the flood that can be expected from the most severe combination of meteorologic and hydrologic conditions considered to be reasonably possible in the region. The probable maximum flood, as the name implies, is an estimate of the upper boundary of flood potential for a drainage area. Such a hypothetical flood is required for designing the spillway for Prado Dam and Seven Oaks Dam. The determination of the probable maximum storms for the drainage areas above Seven Oaks Dam and Prado Dam were based on data obtained in Enclosures one and two of a letter (subject: PMP for 18 Los Angeles basins) dated December 2, 1968, from the Hydrometeorological Branch of the U.S. Weather Bureau. The probable maximum storm, which was based on a general winter storm, was used as the basis for developing the probable maximum flood for Prado Dam and Seven Oaks Dam. A detailed analysis for determining the PMF is presented in section H of the 1975 Review Report.

Probable Maximum Precipitation

SEVEN OAKS DAM

6-02 The average depths of precipitation over the drainage area for 6-, 12-, 24-, 48-, and 72-hours are 10.1, 19.1, 29.7, 41.7, and 47.5 inches, respectively.

PRADO DAM

6-03 The average depths of precipitation over the drainage area for 6-, 12-, 24-, 48-, and 72-hours are 5.6, 10.6, 16.5, 23.1, and 26.3 inches, respectively.

Determination of Probable Maximum Flood

PRADO DAM AND SEVEN OAKS DAM

6-04 Computation of the PMF was accomplished in the same manner as the SPF, with two exceptions. First, basin lag time was reduced by 15 percent to account for the increase in hydraulic efficiency of the watershed due to greater depths of flow. Second, a constant loss rate of 0.15 inch per hour, adjusted for impervious cover, was used. This is the minimum loss rate deemed reasonable for a watershed saturated by antecedent rainfall. The probable maximum flood peak discharge at Prado Dam for present conditions is 670,000 ft^3/s and for future conditions (pl. 7-69), 700,000 ft^3/s. The probable maximum flood peak inflow at Seven Oaks Dam under both present and future conditions (pl. 7-70) is 180,000 ft^3/s. As was done with the SPF, a rainfall-runoff model was used to generate the PMF at Prado Dam and Seven Oaks Dam. From an analysis described in the Phase I Supplement, Seven Oaks Dam has negligible impact on the peak and volume of the PMF at Prado Dam. Hence, the PMF at Prado Dam was the same both with and without Seven Oaks Dam.

VII. SEDIMENT YIELD AND DEBRIS YIELD ESTIMATES

Sediment Yield

SEVEN OAKS DAM AND PRADO DAM

7-01 An average annual sediment yield of 2.3 acre-feet per square mile, as determined in the 1985 Phase I Supplement Report, was used for Seven Oaks Dam. Like Prado Dam, the effective drainage area of Seven Oaks Dam for sedimentation purposes excludes the 38 square miles tributary to Big Bear Lake. Thus, the total effective area for computation of sediment allowance is 139 square miles, which results in a 100-year allocation of 32,000 acre-feet. An average annual sediment yield of 0.75 acre-feet per square mile, as determined in the 1975 Review Report, was used for Prado Dam. Thus, over the project life of 100 years, the sediment allowance is 70,000 acre-feet, determined for an effective sediment-producing area of 935 square miles.

7-02 One measure that may be incorporated into the current design of Seven Oaks Dam that would extend use of the dam beyond the expected project life of 100 years, is to market the sediment that accumulates behind the dam. Southern California is urbanizing at a rapid rate, thus depleting the material available for construction purposes (i.e. aggregate). Marketing the sediment deposited behind the dam would serve the dual purpose of extending the useful life of the dam by restoring reservoir capacity through sediment removal, and providing material necessary to the construction industry in this region.

Debris Estimates

OAK STREET DRAIN

7-03 The recommended plan in the Review Report for Oak Street Drain included a debris basin at the channel inlet above Ontario Avenue. However, the Riverside County Flood Control and Water Conservation District (RCFCWCD), with funds from the Soil Conservation Service,

completed their own debris basin immediately downstream of Chase Drive on Oak Street Drain in October 1979. An estimate was made of the debris production for the combined Hagador, Tin Mine, and Kroonen Canyons at the RCFCWCD debris basin. The debris estimate, based on a single major storm event, was computed using the recommendations of Los Angeles District geologists as to debris potential and the procedure outlined in "A New Method of Estimating Debris-Storage Requirements for Debris Basins", by Tatum. The Tatum method for estimating debris storage requirements is derived from data obtained from watersheds in the San Gabriel Mountains. Hydrologic and geologic conditions in the Oak Street Drain watershed are similar to those found in the San Gabriel Mountains, thus allowing the use of the Tatum method for the Oak Street Drain debris estimate. Debris estimates made using this method are based on drainage area, slope, drainage density, hypsometric index, 3-hour rainfall, and burn (wildfire) effect. To provide continuity for design purposes, the 3-hour rainfall used in the computation of debris was the 100-year 3-hour point rainfall from NOAA Atlas II. This point value (2.8 inches) constitutes a single major event. Table 7-25 presents the debris production factors, and correction factors which resulted in the recommended maximum production rate of 224 acre-feet for the 100-year frequency event. Correction factors are based on graphs shown in the Phase I GDM. The estimated debris yield from a major single event (equivalent to an approximately 100-year debris yield event) from the 6.1 square mile canyon area computed to be 224 acre-feet is comparable to the RCFCWCD design value of 253 acre-feet for the debris basin.

VIII. RESERVOIR REGULATION

Santa Ana River Basin Water Control Plan

GENERAL

8-01 In order to realize the full benefits that can be provided by the Santa Ana River dams and reservoirs described in this report, they must be operated in a manner consistent with authorized project purposes and in coordination with each water control component of the Santa Ana River. The purpose of this section of this volume is to discuss the general plan of water control for the Federally constructed reservoirs both individually and as a system.

8-02 A number of other reservoirs within the Santa Ana River Basin (pl. 7-71 and table 7-26) may affect floodflows. These reservoirs fall into two categories: water conservation reservoirs (some with a large amount of surcharge storage), and flood control reservoirs. Although several of the upstream water conservation reservoirs have enough available storage to affect floodflows, these reservoirs were assumed to be full to spillway crest during the determination of the design flood routing, and the effect of many on controlling the design flood was negligible. Lake Mathews, the largest, is normally full to spillway crest with imported water during the winter flood season. In addition, its drainage area is only 40 square miles. However, considerable regulation could be expected at two water conservation reservoirs: Big Bear Lake and Santiago Reservoir, because of the large amount of surcharge storage available in these reservoirs. Big Bear Lake, with a drainage area of 38 square miles, has a surcharge storage of about 8,000 acre-feet to the top of the dam. Santiago Reservoir, upstream of Villa Park Dam on Santiago Creek, has a drainage area of 63.2 square miles, and about 14,000 acre-feet of surcharge storage. Two existing Corps of Engineers' reservoirs located within the study area, San Antonio Reservoir and Carbon Canyon Reservoir, will also be discussed below. The reservoirs that are the subject of this report are controlled by Seven Oaks Dam, Prado Dam, and the Santiago Creek Reservoir (converted gravel pits). With the exception of Santiago Creek

Reservoir, these reservoirs are authorized as single-purpose flood-control reservoirs. No reservoir storage allocations are provided for other purposes such as water supply, recreation, fish and wildlife, etc. Santiago Creek Reservoir has water supply storage below the flood control storage allocation.

SEVEN OAKS DAM

8-03 Storage allocations for the reservoir behind Seven Oaks Dam below spillway crest are as follows: flood-control storage, 113,600 acre-feet and 100-year sediment storage, 32,000 acre-feet. Seven Oaks Dam flood-control storage will be used to help control flooding on the Lower Santa Ana River below Prado Dam by reducing peak inflow and volume into Prado Reservoir. In addition, Seven Oaks Dam flood-control storage will assist control of flooding on the Santa Ana River between Seven Oaks Dam and Prado Dam. The conditions at Seven Oaks Dam, the local runoff from the drainage area between Seven Oaks Dam and Prado Dam, and the inflow, outflow and storage conditions at Prado Dam will all be used during an actual flood event to determine the proper release rate from Seven Oaks Dam. Stream and rainfall gauges in the Santa Ana River drainage area should be used when determining the proper release from Seven Oaks Dam.

8-04 The debris pool elevation will be 2200 feet NGVD during the first year after completion of the project construction. The debris pool elevation should be adjusted when needed during the project life based on the amount of accumulated sediment in the reservoir near the inlet structure. The elevation of the reservoir bottom near the inlet structure will raise about 165 feet due to sediment deposition by the end of project life. By then, the top of the debris pool would be elevation 2300 feet NGVD, the top of the trashrack.

8-05 During the southern California rainfall-runoff season, any inflow to the reservoir will be stored for the purpose of forming the debris pool. Outflow will not be relesed until the top of the debris pool is reached. When the runoff season has ended, releases will be made from the debris pool in cooperation with the existing ground water recharge and water supply operations downstream of the dam. The reservoir should be dry by the end of August to allow for inspections and maintenance work.

8-06 When the debris pool elevation is reached, outflow from the reservoir will equal inflow up to a maximum of 500 ft^3/s until the water surface reaches elevation 2265 feet NGVD, which is the bottom of the trash rack. While the reservoir's water surface is on the trashrack, from elevation 2265 to 2299, the maximum release from Seven Oaks Dam will be 50 ft^3/s. This lower release rate is necessary in order to keep floating material from collecting on the trashrack and blocking flow into the inlet structure. When the reservoir has risen above the trashrack at elevation 2299, the release plan of outflow equals inflow up to a maximum of 500 ft^3/s will resume. This release will continue until the flood threat at Prado Dam has passed. At that time, flow from Seven Oaks Dam will be increased in increments up to as much as

7,000 ft^3/s, to evacuate the reservoir in preparation for the next flood event. As the reservoir draws down to the trashrack, releases should again be reduced in order to prevent floating material from collecting on the rack.

8-07 No significant water quality problems are anticipated at Seven Oaks Reservoir. Due to the hydrology of the drainage area upstream, long-term impoundment is unlikely. The reservoir will be dry during many months of an average year. The results of the water quality monitoring program for Seven Oaks Reservoir, described in chapter 10, will be used to determine if any operational and/or structural changes should be recommended to improve the quality of the reservoir impoundment or releases downstream.

PRADO DAM

8-08 Storage allocations for the reservoir behind Prado Dam below spillway crest are as follows: flood-control storage, 292,000 acre-feet and 100-year sediment storage, 70,000 acre-feet. Prado Reservoir will be used to control discharge in the Santa Ana River from the dam to the Pacific Ocean so that outflow from Prado Dam when combined with runoff from the drainage area downstream of the dam will not exceed the capacity of the Lower Santa Ana River at any location.

8-09 A debris pool elevation of 490 feet NGVD will be used to submerge the inlet structure. Until the debris pool elevation is exceeded, releases from Prado Dam will be made in coordination with local ground water recharge operations downstream of the dam.

8-10 When the debris pool elevation is reached during a flood event, the basic criteria for regulation of Prado Dam is to incrementally increase releases, as needed, to a maximum flow rate of 30,000 ft^3/s in order to evacuate the reservoir in preparation for the next flood event. However, controlled releases should not cause or contribute to downstream flooding. The actual release rate from Prado Dam will be determined after consideration of a number of upstream and downstream watershed conditions. These conditions include time of the year, rainfall and runoff from the upstream watershed, activities in and conditions of the downstream channel, rainfall and runoff in the downstream watershed, and current and forecasted reservoir inflow, outflow and storage. Stream and rainfall gauges in the Santa Ana River drainage area should also be used when determining the proper release rate from Prado Dam.

SANTIAGO CREEK RESERVOIR

8-11 Santiago Creek Reservoir will have a flood-control storage allocation of 4,620 acre-feet between elevations 274 feet and 298 feet NGVD. A portion of this storage may be used for water conservation depending on the season of the year. That is, the amount of storage above elevation 274 feet NGVD reserved for flood control only, may vary with the time of the year. Storage below elevation 274 feet NGVD will

be used for water conservation. Santiago Creek Reservoir flood-control storage will be used to control discharge in Santiago Creek from the reservoir to the confluence with the Santa Ana River so that outflow from the reservoir when combined with runoff from the drainage area downstream will not exceed the design discharge of Santiago Creek, which is 5,000 ft^3/s at the mouth. Any water control plan developed for Santiago Creek Reservoir should not violate this criteria or be interpreted in a way that violates it. In addition, Santiago Creek Reservoir can be used, if necessary, to help control flooding on the Santa Ana River downstream of the confluence with Santiago Creek by reducing outflow from the reservoir if local conditions warrant it. The stream gauges downstream of the reservoir and at the mouth of Santiago Creek should be used to guide releases from the reservoir.

8-12 The design water control plan for flood control for Santiago Creek Reservoir during December through March is to maintain outflow from the flood-control storage equal to inflow up to a maximum of 3,500 ft^3/s. For the general storm design flood, the 100-year contemporaneous runoff from the area downstream of the reservoir, added to 3,500 ft^3/s outflow from the reservoir, results in a peak discharge of 5,000 ft^3/s at the mouth of Santiago Creek at the Santa Ana River.

8-13 The design water control plan for flood control for Santiago Creek Reservoir during April through November is to maintain outflow from the flood-control storage equal to outflow from Villa Park Dam up to a maximum of 3,500 ft^3/s. For the 100-year flood generated by a local storm, the runoff from the area downstream of Santiago Creek Reservoir could result in a peak discharge of 5,000 ft^3/s at the mouth of Santiago Creek without any outflow from Santiago Creek Reservoir. Therefore, in order for this water control plan to be able to control the 100-year flood generated by a local storm, there must be adequate flood-control storage space available to capture the runoff from the area between Villa Park Dam and Santiago Creek Reservoir, with no outflow from Villa Park Dam.

8-14 The water surface elevations at Santiago Dam and Villa Park Dam upstream of Santiago Creek Reservoir, and the time of the year during which storage is taking place, will be used to determine the starting elevation of flood-control storage (table 7-23). Table 7-23 also shows the corresponding starting elevation of flood control storage for Villa Park Dam as specified by OCEMA's "Villa Park Dam Operation Manual" revised November 1984. The lowest starting elevation of flood-control storage for Santiago Creek Reservoir is 274 feet NGVD. During rising water surface elevations of the reservoir, when the bottom elevation of flood-control storage is reached, the oulet works are operated so that outflow is as specified in paragraphs 8-11 or 8-12 above. During falling water surface elevations, after the peak water surface elevation has occurred, the maximum outflow is maintained until the starting elevation of the flood-control storage is reached.

SAN ANTONIO DAM

8-15 San Antonio Dam was authorized by the Flood Control Act of 1936 as amended by the Flood Control Act of 1938. Construction of the dam was completed on 1 May 1956. San Antonio Dam is located on San Antonio Creek which flows into Chino Creek, a tributary of the Santa Ana River (pl. 7-6). The reservoir behind San Antonio Dam is a single purpose flood-control reservoir with a flood-control storage allocation of 7,620 acre-feet. During flood events, the dam is operated to form a debris pool up to elevation 2164 feet NGVD. Outflow from the dam when the reservoir is below the top of the debris pool is limited to the water conservation capacity of the local ground water recharging operations immediately downstream of the dam. Above elevation 2164 feet NGVD, reservoir releases are increased up to a maximum of 8,000 ft^3/s in proportion to increasing water surface elevation.

CARBON CANYON DAM

8-16 Carbon Canyon Dam is a single purpose flood-control dam with a flood-control storage of 6,114 acre-feet at spillway crest. It is operated to provide flood-control protection to the urban areas downstream of the dam. The regulation plan calls for a debris pool to be stored up to elevation 419 feet NGVD during flood events. Outflow from the dam when the reservoir is below the top of the debris pool is coordinated with the local ground water recharge operations in the Lower Santa Ana River. Once the debris pool elevation is reached, outflow from dam is increased up to a maximum of 1,100 ft^3/s in proportion to increasing water surface elevation.

PROJECT REGULATION

8-17 The preceding paragraphs provide general criteria for water control at the projects to be built or modified for the Santa Ana River Project. Various paragraphs throughout this volume refer to reservoir regulation schedules for these projects. These schedules were used as fixed operating plans while determining the effects of the flood control reservoirs during various design floods. Actual regulation of these reservoirs will be in accordance with the water control manuals for each project to be prepared by the Los Angeles District upon completion of the project. These flood control reservoirs are part of a reservoir system and as such should be regulated by a single reservoir control center. The Los Angeles District element responsible for water control management will determine the coordinated and individual regulation of the Federally operated flood control reservoirs. Real-time information on reservoir and watershed conditions along with forecasts of future rainfall and runoff will be collected and/or generated by this office. Specific instructions for operation of outlet works will be issued by this office to dam tenders at each of the projects. Actual operation of outlet works will be done by these dam tenders. Remote controlled operation, as opposed to on-site operation, of outlet works reduces the certainty and safety of the control of reservoir releases. Therefore, each reservoir project will have a dam tender on duty during flood events as requested by the District's water control management personnel.

RUNOFF FORECASTING

8-18 Forecasts of runoff from the Santa Ana River Basin will be utilized to assist water control managers in making reservoir regulation decisions. Runoff forecasts will be generated by the National Weather Service's California-Nevada River Forecast Center and/or by the Los Angeles District. One runoff forecast model is the Santa Ana River Real-Time Water Control System developed by the Los Angeles District in February 1987. During certain conditions runoff forecasts could provide enough lead time so that reservoir regulation decisions will be made in advance of when they would be made without forecasting and thereby improve the ability of the system to control the flood. The Los Angeles District will continue to operate and maintain a Water Control Data System for the Santa Ana River Basin to receive and process field data for use in determining watershed conditions and forecasts of future runoff. This system includes rainfall, streamflow, and reservoir water surface gauges located in enough locations throughout the basin to adequately model actual conditions as they occur. These gauges will transmit their measurements by radio to the District office Water Control Data System computer for processing. This computer will be programmed, operated, upgraded as necessary, and maintained to assist water control managers by automatically receiving and analyzing this real-time hydrometeorological data.

WATER CONTROL DOCUMENTATION

8-19 As detailed in EM 1110-2-3600, "Management of Water Control Systems", specific documents will be prepared for some of the reservoir projects. These documents are:

a. Standing Instructions to the Project Operator for Water Control. These instructions apply to dam tenders and are intended to ensure efficient and safe operation of the project within design limitations during all phases of the project life, including construction. These instructions will be prepared for Seven Oaks Dam, Prado Dam, and Santiago Creek Reservoir.

b. Interim Water Control Plan. These water control plans are developed to ensure that water resource projects perform safely and effectively during construction or modification. They are completed prior to the date alteration of the watercourse first occurs, or when the construction site becomes subject to flood damage. Interim water control plans remain in force until the project is formally accepted for full-scale operation. Interim water control plans will be developed for Seven Oaks and Prado Dams.

c. Preliminary Water Control Plan. These plans are developed to describe the plan of water control during the first year of operation. It includes specific regulating objectives, constraints, and procedures. Preliminary water control plans will be developed for Seven Oaks and Prado Dams.

d. Water Control Manuals. Water control manuals will be prepared within one year after a project begins operation. These manuals specify the actual water control plan for the reservoir, facilitate the use of specific reservoir regulation information, and aid in the water control decision-making process on a real-time basis. Water control manuals will be developed for Seven Oaks and Prado Dams.

e. Master Water Control Manual. A master water control manual will be prepared for the Santa Ana River Basin. It will describe the coordinated system operation of the Federally constructed flood-control projects and describe an overall integrated water control plan to accomplish "system" objectives.

Data Collection and Communication

HYDROMETEOROLOGICAL INSTRUMENTATION

8-20 In order to ensure that water control managers understand real-time conditions of the Santa Ana River Basin and to gather information necessary for runoff forecasting, a network of streamflow, precipitation, and reservoir water surface elevation gauges will be installed and maintained. Many gauges are currently in place to facilitate operation of existing projects. These gauges are connected to radio telemetry equipment so that current readings can be transmitted to the District Office. Further explanation of the radio telemetry system is provided below. Precipitation gauges located at existing National Weather Service stations were chosen because information from those areas is needed to determine area average precipitation and they have an established record for use in statistical analysis. Precipitation gauges located at reservoirs and stream gauges were chosen because data is needed from these areas and/or because adding a tipping bucket precipitation gauge to a telemetry station is a cost effective way of obtaining rainfall data. The exact type of gauge equipment for each reservoir project is discussed in the "Hydrologic Facilities" section of the volume for that project. Additional streamflow and precipitation stations with radio telemetry equipment will be installed in the basin to improve coverage of rainfall and streamflow data so that the watershed status can be better defined so the Santa Ana River runoff forecasting model will have sufficient information to produce runoff forecasts for Seven Oaks Dam, Prado Dam, and Santiago Creek Reservoir. The type of new equipment and their location to be installed as part of the Santa Ana River project are shown on table 7-27.

OUTLET GATE RECORDERS

8-21 Each outlet service gate for the reservoir projects will have an automatic recorder to document all gate movements. These recorders will monitor gate settings and make a permanent record of them. They will be connected to the gate control mechanisms and the radio telemetry equipment. The recorders should be automatically activated each time a

gate control switch is activated and a paper recording of the new gate setting with the date and time will be made. This information will then be transmitted to the Distict Office via the radio telemetry equipment.

SEDIMENT RANGES

8-22 At least three monumented sediment index ranges will be established within the reservoir areas of Seven Oaks and Prado Dams. These sediment ranges will be used to indicate the need for updated topographic mapping of the reservoir area (ref. EM 1110-2-4000). Up-to-date topography is essential to accurate computations of reservoir storage, inflow and outflow.

DATA COMMUNICATION NETWORK

8-23 The hydrometeorologic instrumentation located throughout the Santa Ana River Basin will automatically sample their respective parameters at predetermined intervals. If a measurement is different from the previous measurement by a certain amount, the new measurement will be automatically transmitted to the District Office and the flood control offices of the local project sponsors by the data communication network. The equipment used to perform this function consists of a programmable micro computer module, an interface with the hydrometer sensors, an uninterruptible power supply, and a radio receiver/transmitter module. This equipment configuration is known as a "remote terminal unit" (RTU) in the existing Los Angeles District's Water Control Data System. All hydrometmeteorological instrumentation installed as part of the Santa Ana River Project will have RTU's also installed in order to transmit measured information into the District Office and at each of the concerned flood control offices. These RTU's must be fully compatible with the existing system's equipment. The existing system uses line-of-site radio to transmit to the District Office. Radio repeaters located at high elevations (Mount Disappointment and Pleasants Peak) retransmit RTU signals into the system's central receiver. Remote programming and control of an RTU can be performed from the central receiver station. Because of the remote location of the Seven Oaks Dam drainage area, establishing a radio path between one or more of the new RTU's and an existing repeater station will be difficult, and in some cases, impossible. Therefore, the radio repeater network will have to be expanded so that radio signals can be relayed into the District Office and flood control agencies from the new and existing RTU's. In addition, to provide telemetry information to the local sponsors of the project, a telemetry radio receiver and microcomputer will be installed at each flood-control office of the local project sponsors. These telemetry central stations will be able to receive all of the transmissions from the RTU's located within the Santa Ana River drainage area. The radio repeater network will also be modified so that microwave transmissions from the mountaintop repeater stations will be relayed to the central stations at the flood control offices.

COMMUNICATION BETWEEN DAM OPERATORS AND THE DISTRICT OFFICE

8-24 Commercial telephone service will be provided to the control houses of Seven Oaks and Prado Dams and the Santiago Creek Reservoir. In addition, an FM radio transceiver will be located in the control houses of Seven Oaks and Prado Dams that will transmit on the Los Angeles District voice radio network. The radios would be connected to the standby power systems to ensure communication with the control houses in the event of loss of power or telephone service.

IX. WATER CONSERVATION

General

9-01 Prado Dam and Reservoir is congressionally authorized to provide flood protection to the residents of Orange County downstream of the dam. During times of low flood threat, the dam may be used to regulate the Santa Ana River such that outflow from the dam will not exceed the capacity of the Orange County Water District (OCWD) ground water replenishment facilities downstream of the dam. When the dam is regulated in this manner, Santa Ana River water is used to recharge the OCWD ground water aquifer, and runoff lost to the Pacific Ocean is minimized.

9-02 The current approved flood control operation plan for Prado Dam includes relatively low release rates from Prado Dam at elevations 490 feet NGVD and below.

9-03 Estimates of the quantity of water available for recharge by OCWD were determined; (a) under present conditions for the existing Prado Dam; (b) using the release schedule published in this report for the recommended Prado Dam; and (c) historical operations.

Water Conservation Analysis

9-04 Estimates were made by utilization of an HEC-5 simulation model for daily flow values for the period 1950-86, adjusted upward to account for increases in urbanization and wastewater effluent return. Discussion of the adjustment made to the daily flow values to emulate present conditions is found in paragraph 5-20. The existing Prado Dam release schedule (table 7-28) was used for existing conditions, and the recommended Prado Dam release schedule (table 7-14) was used for

Phase II conditions. No deviations were made to the schedules, and no adjustments were made to account for watershed conditions, forecasting, or downstream channel conditions. Local incremental flows originating in the drainage area between Prado Dam and Imperial Highway were estimated based on the gauge records below Prado Dam, at Imperial Highway, and using correlation with rainfall amounts. These flow values were also adjusted for urbanization. These local runoff values were then added to Prado Dam releases to establish the total daily flows reaching the OCWD diversion site. The monthly recharge capability (in ft^3/s) by OCWD is as follows:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
300	200	200	240	260	280	300	300	300	300	300	300

An additional estimate was made resulting from historical operations at Prado Dam. The amount of water conserved as the result of historical operation of the dam was based on OCWD estimates of Santa Ana River streamflow recharge and losses to the ocean for the years 1973 through 1985.

9-05 The simulation results show very little difference in recharge values between the existing Prado Dam and the recommended Prado Dam. The values for average annual recharge are 107,815 acre-feet, and 107,924 acre-feet for existing and Phase II conditions, respectively. The average annual recharge under historical operations is estimated at 116,000 acre-feet, approximately 75 percent of the total runoff available at the recharge facilities, in contrast to 69 percent of the total runoff for the simulated "with" and "without" project operations. The higher value under historical operation is due to deviations from the schedule due to downstream channel constraints and from storing water above elevation 490 feet NGVD when conditions permit.

9-06 The historic operation of Prado Dam has resulted in greater recharge to ground water aquifers than that indicated by hydrologic simulation. However, it should be noted that those amounts delivered historically cannot be guaranteed in the future. While the simulated average annual recharge estimates represent only a potential based on known conditions, implementation of a seasonally-expanded water conservation operation would allow, with reasonable certainty, delivery of water at rates optimum for recharge at the downstream recharge basins, given sufficient inflow to Prado Dam after the flood season. No assumptions should be made that water will be released from Prado Dam in a manner similar to that of previous years. The certainty of receiving similar amounts from Prado Dam at water conservation release rates cannot be assured.

X. WATER QUALITY

General

10-01 This section assesses existing water quality and identifies potential changes to water quality associated with the construction and operation of the recommended flood control reservoirs. The potential impacts of these projects on water quality were identified at public workshops as a major concern of local residents. Specific tasks of this investigation included data collection, and a literature search for existing water quality information; identification of beneficial uses and water quality objectives; interviewing the California Regional Water Quality Control Board (CRWQCB), Santa Ana Region, and local water control agencies; assessment of changes to water quality from construction operations, and a new water control plan of operation; an evaluation of the water quality aspects associated with flood control and incidental water supply at Prado Reservoir; and recommendation of mitigation measures to avoid or lessen deleterious changes.

10-02 Certain water quality criteria must be met in order to maintain the character of surface and recharged ground waters. Guidelines concerning the Federal Government's role in water quality for its reservoirs are included in ER 1110-2-1402 and EP 1165-2-1. These stipulate that State standards should be met whenever feasible. California's Porter-Cologne Water Quality Control Act of the State Water Code (1969), has established this responsibility and authority to the CRWQCB. The CRWQCB (Santa Ana Region) has identified beneficial uses and objectives regarding water quality for impounded water. These objectives are addressed in the following paragraphs.

Data Acquisition

SEVEN OAKS RESERVOIR

10-03 Stream gauges nearest to the Seven Oaks damsite which are used in measuring water quality are located within one mile of the damsite. They are located in close proximity to one another near the town of

Mentone on the mainstem of the Santa Ana River. Data from USGS's 11051500 (10/71-7/84), and the CRWQCB's Y517000 (8/66-1/77) and Y5197800 (1951-1986) were used in the analysis. Since water quality data in the upper reaches of the Santa Ana River is scarce, data from these stations were combined to form a larger data base. A statistical summary of the combined data base was obtained using the Environmental Protection Agency's (EPA) Water Quality Control Storage and Retrieval system (STORET).

PRADO RESERVOIR

10-04 Data from three stream gauge water quality monitoring stations located in the immediate vicinity of Prado Dam were examined to characterize existing water quality conditions. Two of the stations are located approximately 12 miles upstream of the dam at the Metropolitan Water District's crossing near Arlington; USGS's 1106646 (8/69-3/86) and CRWQCB's Y6141000 (1/74-10/86). The third USGS gauge, 11074000 (10/66-3/86), is located immediately downstream of Prado Dam. A statistical summary for these stations was obtained using the EPA's STORET system. When possible, data from 1980 to 1986 were compiled to obtain a more recent representation of water quality.

Water Quality Background at Prado Reservoir

10-05 The quality of water in the Santa Ana River Basin in the vicinity of Prado Dam is directly influenced by the quality of inflows into the basin. This inflow consists of surface flows from the Santa Ana River and several tributaries (Cucamonga Creek, Chino Creek, and Temescal Wash), rising ground water, municipal sewage effluent, and/or non-point discharges (urban and agricultural runoff). Intermittent flow is generally of good quality, improving after the start of the runoff season in January, when "flushing" in the watershed is occurring. The highest quality inflow to Prado Dam occurs during February and March. Inflow to Prado Dam remains perennial due to discharge from sewage treatment plants and rising ground water. These two components, along with non-point source discharges, make up the baseflow in this reach of the Santa Ana River. In general, water quality is degraded by these baseflow components.

10-06 The degradation of baseflow is illustrated as a time-series plot of electrical conductance at the outlet at Prado Dam (pl. 7-72). Conductance levels have been identified as a general indication of water quality. They fluctuate greatly in January as a consequence of flushing action and the intermittent nature of higher quality natural inflow, and are at their lowest levels in February and March. Conductance levels then increase during the summer months, reaching their highest point in August after the reservoir is drained. During this time, the volume of rising ground water and non-point source discharges tend to be low; thus the baseflow may contain as much as 95 percent treated municipal effluent. Water quality objectives upstream of Prado Dam are based on baseflow rather than on total flow since the former can be controlled through regulatory action by the CRWQCB.

SEVEN OAKS RESERVOIR

10-07 The CRWQCB has identified beneficial water uses (table 7-29) for the reach of the Santa Ana River extending from the confluence with Bear Creek to the San Jacinto Fault at the interchange of Interstate Highways 10 and 15. Beneficial uses, simply defined, are the many ways water may be used, either directly by the public, or for other benefits. The California Porter-Cologne Act (1969) defines water quality objectives as, "...the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area". The CRWQCB has established water quality data and water quality objectives for this reach (tables 7-30 and 7-31). The CRWQCB also lists criteria (table 7-31) which prohibit the direct dumping of chemicals and compounds into the river, including many toxic substances, pesticides, radioactive materials, and organic compounds, such as PCBs or phenols. In addition, the CRWQCB recommends reasonable limits on "floatables", oil and grease, turbidity, algae, color, taste, and odor in order to maintain the esthetic quality of the water.

PRADO RESERVOIR

10-08 The CRWQCB has identified six beneficial water uses for the Santa Ana River near Prado Dam. These include agriculture, ground water recharge, contact recreation (swimming and fishing), non-contact recreation (picnicking and boating), warm water habitat, and wildlife habitat. The waters around Prado Dam have not been designated as a municipal source, although they are used for ground water recharge downstream of the dam.

10-09 Prado Dam serves as a physical barrier between the Upper and Lower Santa Ana River systems. Since water quality, at times of storage, differs between reaches upstream and downstream of the dam, separate criteria (table 7-32) are given to maintain the aforementioned uses. In table 7-33, additional standards which are common for both reaches were established by the CRWQCB. The CRWQCB also lists substances (table 7-33) which are prohibited from being dumped directly into the river, including toxics, pesticides, radioactive materials, and organic compounds, such as PCBs or phenols. Municipal objectives exist for trace elements such as arsenic, barium, cadmium, cyanide, iron, lead, mercury, and nitrates. Objectives (table 7-33) do not have regulatory impact for this reach of the Santa Ana River, but they do present guidance to recognize potential hazards in the environment. In addition, the CRWQCB recommends reasonable limits on floatables, oil and grease, turbidity, algae, color, taste, and odor, in order to maintain the esthetic quality of the water.

Existing Water Quality

SEVEN OAKS RESERVOIR (UPPER SANTA ANA RIVER)

10-10 Inspection of tables 7-30 and 7-31, indicates that in general, the water quality parameters in this reach of the Santa Ana River are well within the objectives (some of which are for drinking water) established by the CRWQCB. Total dissolved solids (TDS) range from 232 to 82 mg/l. The dissolved solids are composed of common materials of low toxicity, such as calcium, sodium carbonates, chlorides, and sulfates. Dissolved oxygen (DO) is near the saturation level. The only exceptions which may give cause for concern are total coliforms, unionized ammonia, and DDT. However, the available data for these parameters is insufficient to form any definite conclusion. Total coliform counts of 24,000/100ml have been reported after major storm events. These high values are due to surface runoff from agricultural and livestock grazing areas, and/or to the dislodging of bacterial colonies on the stream bottom. DDT was a common pesticide used in the 1970's; since it is a highly persistent chemical with bioaccumulative properties, it may still show up in present-day water analyses. Action by the EPA in suspending the production and use of DDT should result in a gradual decline in concentrations found in the environment.

PRADO RESERVOIR

10-11 With respect to the objectives listed in tables 7-32 and 7-33, the CRWQCB identifies the increasing amount of dissolved minerals (TDS) as the major water quality problem in this reach of the Santa Ana River. In recent years, the amount of TDS in the August baseflow has remained relatively steady; in the range of 700-750 mg/l. Stormflow contains a distinctly lower level of TDS than that of the baseflow. During the storm season (January through March), a low value of TDS, 100 mg/l, suggests a great improvement in the chemical quality as compared with the previous season, which is dominated by baseflow. As seen in table 7-32, the mean annual values of TDS in Santa Ana River inflow to, and outflow from, Prado Dam are 602 and 641 mg/l, respectively. On the average, outflow downstream of Prado Dam has higher concentrations of TDS than Santa Ana River inflow. This is apparently due to flow from tributaries and ground water flowing into the basin, which have a higher TDS content than the Santa Ana River. For the period of record (1969-1986), concentrations of TDS exceeded the CRWQCB objective approximately 35 and 60 percent of the time in the upstream and downstream reaches, respectively. The major factor contributing to this observation was the treated effluent within the baseflow component. Typical sewage treatment in this area removes organic matter, measured by Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), but has little effect on the reduction of TDS. Thus, effluent may be expected to maintain a high content of dissolved solids. Future TDS levels from treatment plants are expected to increase in the future (table 7-34). To meet the standard on future loads, new methods of treatment and/or treatment facilities, along with the continued enforcement of discharge management practices is necessary.

10-12 Parameters which are also highly dependent on treated effluent include nitrogen and ammonia. The standard for un-ionized ammonia downstream of Prado Dam has been exceeded in the past. In 1986, however, the mean concentration for ammonia was 0.0623 mg/l, and all samples taken were within the CRWQCB's standard of 0.8 mg/l. In the future, the likelihood of maintaining acceptable levels of nitrogen and ammonia is uncertain. Waste allocations from treatment plants which directly or indirectly flow into the Santa Ana River between Riverside and Prado Dam are illustrated in table 7-34. Limitations on concentrations of ammonia and total nitrogen (table 7-32) are expected to protect aquatic life and ground water quality in the basin. Built into these limitations is an assumption about the assimilative capacity of the river to reduce effluent concentrations to acceptable levels.

10-13 Other parameters exceeded in the past include; fecal coliform, copper, and zinc. The bacteriological quality of Santa Ana River water is not good, based on the limited available data. The amount of coliform bacteria varies widely over both time and space. Contamination may be due to the inflow of runoff from dairy and other pasture land, since a marked increase in the level of bacteria occurs following a storm event. Total coliform counts ranging from 20 to 140,000/ml have been reported. These large amounts could be due to surface runoff from agricultural and grazing areas and/or to the dislodging of bacterial colonies from the stream bottom. More than half of the water samples analyzed for copper and zinc taken upstream of Prado Dam during the 1970's exceeded the objectives. This may have occurred because some of the treatment plants (Colton, San Bernardino, and Rialto) receive inflows from industrial discharges. However, in 1986, the mean copper and zinc concentrations were 0.0027 and 0.018 mg/l, well within acceptable limits.

10-14 The CRWQCB prohibits the direct discharge of some substances because of their bioaccumulative properties and carcinogenic potential (some are identified by "*" in table 7-33). Note that concentrations of many of these substances exceed the CRWQCB's objectives for municipal water supplies, and the EPA's standards for aquatic life. In 1983 and 1984, several organic compounds (DDT, DDE, and PCBs) were detected in fish tissue. The contaminant levels indicate the availability (to aquatic life) of those substances most likely found in the sediment and water. Although some contaminants may still be introduced into the river through illegal dumping activity and non-point sources, a gradual decrease in concentration can be achieved by more stringent protective measures.

Effects of Construction

10-15 Construction of the main embankment at Seven Oaks Dam will take approximately 5 years. During the construction phase, changes to water quality are expected to be similar to those of any large construction project. Erosion resulting from site preparation, placement of fill for cofferdams, and diversion of water to side channels may result in a

temporary increase in turbidity. The CRWQCB has set a limit of a 20 percent maximum increase over the natural turbidity of a stream due to construction activity. Because the water is currently very low in turbidity, compliance with this objective during the construction phase will require great care. In addition, if not managed carefully, wastewater from construction practices may introduce contaminants such as oil products, fuels, chemicals, and lime into the water. Water quality prohibitions are quite strict in this regard. Sources of these contaminants would include equipment cleanup, aggregate washing, concrete cooling, and accidental spills.

10-16 Measures to mitigate potential contamination are considered in the design phase of the project. Erosion can be minimized by careful use of grading management techniques, drainage ditches, and baled straw. Procedures for controlling surface fluids (water, oil, gasoline, asphalts, and wet concrete) include the use of check dams for drainage control, collecting waste fluids in ponds or other retention structures, installing equipment to avoid spills, providing concrete or asphalt wash pads for cleaning trucks and other construction equipment, and properly designing concrete equipment cleaning areas.

Effects of Flood Control and Water Storage Operation

SEVEN OAKS RESERVOIR

10-17 The water control plan at Seven Oaks Dam employs a debris pool made up principally of storm water runoff. The top elevation of the debris pool is normally established to provide sufficient water depth to fully submerge the outlet gates and to prevent the formation of vortices which would tend to draw floating debris into the gate openings. Also, the pool forms a still (zero velocity) body of water that prevents the movement of heavy bedload material into the outlet gates. Inflow, beginning on 1 October each year, will be captured to achieve the desired debris pool elevation of 2200 feet NGVD; however, this elevation for present conditions will be realized in about one out of three years due to low flow conditions. The operation schedule requires the pool to be fully drained by the end of August. This will be accomplished by releasing 10 ft^3/s plus inflow (if any) during June, and 20 ft^3/s plus inflow (if any) during July and August. Following this plan will always result in an empty reservoir by the end of August.

10-18 Concern over the possible adverse effects to water quality that the debris pool will create have been noted. In general, water quality is degraded by extended impoundment in long, deep storage pools, especially during the summer months when higher temperatures cause stratification and associated low levels of dissolved oxygen (DO). Along with severe anaerobic conditions, the generation of hydrogen sulfide typically commences when materials containing sulphur (biological detritus and mineral sulfides) are available. Trace metals found in bottom sediments may be released by the lowering of pH which occurs as a result of anaerobic conditions. Local nuisance conditions

such as algal blooms and mosquito breeding may also occur. Associated with these adverse effects of impoundment are also inherent benefits to water quality including the settling out of suspended solids and detritus. Benefits as a consequence of dilution is the reduction of TDS. These factors may outweigh those detriments associated with low levels of dissolved oxygen and pH.

10-19 The extent to which adverse effects to water quality are realized is highly dependent on the length of storage. During an average runoff year, the debris pool storage at Seven Oaks Dam may experience some stratification if wind action is not strong enough to induce mixing. Also, the frequency of flood flows into the reservoir during the summer will not be sufficient to disrupt the stratification process. Should stratification take place, however, the hypolimnion (layer near the lake bottom) is not likely to become anaerobic. The main reason for this premise is that water from levels at or near the hypolimnion will be released to satisfy downstream requirements during the summer months. Also, the quality of water flowing into the reservoir is good, BOD and COD are generally low, and DO is high. If a portion of the stored water did become anaerobic, acidic conditions would tend to be counteracted by the buffering capability (high pH) of the inflowing water.

PRADO RESERVOIR

10-20 During the non-flood season, baseflow will not be stored, but will pass immediately downstream, with little change in water quality except for that due to mixing with other inflows. Water will be impounded to the debris pool elevation of 490 feet NGVD during the winter storm season for flood control requirements. Impoundment of flood runoff for short periods of time with slow drawdown (normal flood control operations) has had little adverse effect on water quality. The effect of short-term impoundment on water quality would most likely be beneficial, as floodwaters containing a low concentration of TDS would dilute baseflow containing a higher concentration of TDS.

10-21 Occasionally, extended impoundment within the flood pool may be necessitated by high storm runoff and downstream channel repairs, as was the case in 1980 and 1983. In 1980, after 6 months of impoundment, the water pool was found to be highly stratified and anaerobic in the bottom half. In general, water quality is degraded by long-term storage in deeper, more stable pools, especially over the summer months when higher temperatures cause stratification and associated low levels of DO. Along with anaerobic conditions, the generation of hydrogen sulfide may occur, initiating a reduction in pH. In 1983, water was held in storage until June. During the time of storage, local nuisance conditions such as algal blooms, and mosquito breeding were evident.

10-22 Overall, the impoundment of floodwater is expected to have beneficial effects on water quality. Typically, concentrations of suspended solids (SS) and nitrates are lowered, and to a limited extent, TDS. The benefits associated with these reductions must be considered in conjunction with the detriments associated with potentially low

levels of dissolved oxygen and pH reduction. Water samples taken below the dam have not shown significant lowering in DO and pH after extended impoundment. The growth of algal blooms due to the impoundment of floodwaters was examined and judged to have minimal effects in the reservoir. Concern for their growth appears to be warranted only when major infrequent floods occur where impoundments could extend long into the summer months.

10-23 A new water control plan of operation was developed for Prado Dam. The impacts the new plan will have on water quality are anticipated to be minimal. The new plan is very similar to the actual historical operation of the existing Prado Dam for releases of up to approximately 5,000 ft^3/s and will inundate less land during major flood events (10-100 year frequency). Nutrients represented by BOD, Total Organic Carbon (TOC), phosphates and nitrogen released from pastures and agricultural land will have less chance of reaching the storage pool.

Effects of Rising Ground Water

10-24 The construction of the Seven Oaks Dam will have an effect on the ground water regime within the immediate vicinity of the damsite. Ground water will be forced to the surface, and mixed with lower quality surface water. However, little or no impact to water supply should occur, since no underground collector pipe or municipal water wells is located immediately downstream of the dam. Existing diversion works about 1 mile downstream of the dam convey surface flow to existing recharge basins and surface distribution facilities.

Effects of Recreation

10-25 Although public access is limited, Seven Oaks damsite offers recreation opportunities in hiking, backpacking, and other nature related activities. This anticipated low recreational usage at Seven Oaks Dam is expected to continue and may increase the concentration of coliforms in the water. Off-road vehicle use will not be permitted in the reservoir area. Because recreational usage at the spreading grounds and distributing facilities will be controlled, impacts on water quality will be minimal.

Mitigation Measures

10-26 The Porter-Cologne Act specifies that a quality control plan be implemented to accomplish the established water quality objectives. The CRWQCB's Recommended Basin Plan for the Santa Ana River is a composite of plans, projects, and ongoing programs. Baseflow dilution, as a consequence of flood storage at Prado Dam, would promote CRWQCB objectives in accordance with the Recommended Basin Plan. Incidental to flood control operation, the Phase II Water Control Plan for Prado Dam provides releases that can be utilized for downstream recharge and limits the amount of storage time without adversely affecting water quality.

Recommended Water Quality Monitoring Program at Seven Oaks Reservoir

10-27 A water quality monitoring program would be initiated at Seven Oaks Reservoir to establish a data base on those chemical, limnological, and bacteriological parameters that could adversely impact the environment in the upper Santa Ana River Canyon. The parameters should be monitored during the months of January, April, May, June, and October, when water is present in the reservoir pool. The results of the water quality monitoring program will be analyzed each year to determine necessary changes to the following year's monitoring program.

CHEMICAL PARAMETERS

10-28 As a minimum, the chemical parameters that would be monitored are NH_3 + NH_4 (Total Ammonia), NO_2, NO_3, chlorophyll-a, pheophytin-a, the chlorophyll-a/pheophytin-a ratio, and DDT. The parameters would be monitored at three levels; (a) on the surface near the dam intake structure; (b) near the thermocline (either immediately above or immediately below); and (c) at the bottom of the reservoir pool. If no distinct thermocline exists, then the depth would be halfway between the surface and bottom depths.

LIMNOLOGICAL PARAMETERS

10-29 The limnological parameters that would be measured are temperature, pH, dissolved oxygen, and specific conductivity. They would be monitored on the surface near the dam intake structure and at 15-foot depth increments to a depth of 190 feet.

BACTERIOLOGICAL PARAMETERS

10-30 The bacteriological parameters that would be measured are total coliform, fecal coliform, and fecal streptococci. They would be monitored at the surface, near the thermocline (either immediately above or immediately below), and at the bottom. If no distinct thermocline exists, then the depth would be halfway between the surface and bottom depths.

DOWNSTREAM WATER QUALITY MEASUREMENT

10-31 Water quality measurements will be made at the USGS gauge No. 11051500 located downstream from Seven Oaks Dam. Measurements will include all of the limnological and bacteriological parameters listed in the sections above, and all of the chemical parameters listed with the exception of the chlorophyll-a, pheophytin-a and the chlorophyll-a/pheophytin-a ratio. Each parameter will be measured at only one depth, since the flow will normally be shallow.

XI. GROUND WATER

Effect of Recommended Prado Dam on Reservoir Ground Water Levels

11-01 The effect that the recommended Prado Dam will have on ground water levels within the reservoir was determined by examining the elevation-duration-frequency curves (existing dam vs. recommended dam) for both present and future conditions (pls. 7-41 through 7-44). Evaluation of each condition is based on consideration of the pool depth and duration of inundation for each of the elevation-duration-frequency curves. By superimposing the recommended dam curves onto the existing dam curves, the water levels for similar frequencies were compared.

11-02 For all elevations within the reservoir, the recommended dam would cause a smaller rise in ground water levels after a flood event than would have been experienced with the existing dam. The difference would be greater for less frequent events (i.e., 100-year, 50-year, 25-year) for both present and future conditions. An exception to the general reduction in water levels would be for events more frequent than the 5-year future condition level. During these events (i.e., 2-year to the 5-year frequency of occurrence), a very slight increase may occur in the ground water levels due to the fact that the pool level of the recommended dam would be at a higher elevation than that of the existing dam for a greater part of the year. The slight increase in ground water levels would only occur below a ground elevation of 510 feet NGVD.

XII. INTERIOR FLOOD CONTROL

General

12-01 Interior flood control refers to drainage from areas protected from direct river flooding by levees or floodwalls. The project reach of the lower Santa Ana River extends about 31 miles from Prado Dam to the Pacific Ocean (pls. 7-7 through 7-10). The drainage area downstream of Prado Dam (pls. 7-7 through 7-10 and tables 7-7 and 7-8) totals about 200 square miles, with Santiago Creek at 102 square miles being the largest tributary. The largely undeveloped Chino Hills and Santa Ana Mountains upstream of Imperial Highway encompasses about 50 square miles. Carbon Canyon Diversion Channel and Greenville-Banning Channel drain about 18 and 10 square miles, respectively. The remaining 20 square miles includes all the small urbanized areas draining into the Santa Ana River. Upstream of the dam along the perimeter of Prado Reservoir, dikes will be required in four different locations (pl. 7-73) to protect structures or facilities located below elevation 566 feet NGVD. Drainage facilities and ponding areas will be built to control runoff behind these dikes as a result of the local SPF. Two auxiliary dikes (along the railroad to the east and along Highway 71 to the west) will be required to contain the PMF pool. The reach of the river from Prado Dam to about 7 miles downstream is known as the Santa Ana River Canyon, and will remain basically unimproved, except for a 1,900-foot levee to protect the mobile home community located near the Green River Golf Course just downstream of the railroad crossing. From the end of the canyon reach (at Weir Canyon Road) to about 17th Street in Santa Ana, the channel levee heights are generally 2-4 feet above the general grade line. From 17th Street to the Pacific Ocean, the levee heights increase to 10-15 feet above the general grade line. For the recommended project improvements, the river alignment and channel levee elevations will remain essentially the same. However, the invert will be lowered considerably in the lower 8 miles of the river. The mainstem flood control channel will be designed to carry a maximum regulated release of 30,000 ft^3/s from Prado Dam. Combining local tributary inflows with the maximum regulated release at Prado Dam, the channel design discharges range from 38,000 at Weir Canyon Road to 47,000 ft^3/s

downstream from the confluence with Greenville-Banning Channel. The interior areas draining into the project channel "line-of-protection" were analyzed for three flood conditions:

a. Flood condition 1 : 100-year local storm peak discharges in the side drains and contemporaneous local storm peak discharges in the river.

b. Flood condition 2 : SPF local storm peak discharges in the side drains and contemporaneous local storm peak discharges in the river.

c. Flood condition 3 : Contemporaneous general storm peak discharges in the side drains and design discharges in the river.

Flood condition 1 was considered the minimum design level for all side drains. Residual overflow areas were determined for flood condition 2. Flood condition 3 was determined to be less critical for design purposes than flood condition 1, that is, it produced a lower water surface elevation in the side drain or interior areas.

12-02 The area along the northwest bank of the Santa Ana River from the Pacific Ocean to near the Harbor Boulevard Bridge drains away from the Santa Ana River and into Talbert Channel, except in four localized areas where the storm runoff is collected and pumped into the river. Along the southeast bank of the river south of the 1st Street Bridge in the city of Santa Ana, the Greenville-Banning Channel collects storm runoff and carries it parallel to the river before discharging into the Santa Ana River at the downstream end of the Victoria Street Bridge. Upstream of these two drainage basins (at Harbor Boulevard and the Greenville-Banning Channel) to the Weir Canyon Road bridge, are a series of storm drains that collect storm runoff and discharge it into the Santa Ana River. Design hydrographs for the interior drainage areas were determined using both local SPF and 100-year flood events.

Standard Project Flood

12-03 The March 1943 local thunderstorm, transposed directly over the study area, was used to determine local SPF peak discharges (table 7-35) and hydrographs on the Santa Ana River mainstem and interior areas. The storm was successively centered upstream of each location of interest on the river. Subarea hydrographs were generated, routed, and combined to produce the mainstem discharges. The storm was also centered over each individual subarea (tables 7-7 and 7-8) to generate subarea hydrographs. For the analysis in this report, the peak discharge on the side drain was adjusted in time to occur simultaneously with peak discharges on the mainstem. This condition was used for side drain design and to obtain the ponded water surface elevation for the interior area. This condition of simultaneous hydrographs actually provides for a contemporaneous peak discharge in the mainstem of an approximate 30- to 60-year event

based on the discharge-frequency relationship of the mainstem. This frequency of contemporaneous flow for the mainstem is consistent with historic events and with studies made for similar areas in southern California.

100-Year Flood

12-04 The local 100-year hydrographs and discharges (table 7-36) were determined directly as a ratio of the SPF values. Regionalized parameters developed in the Review Report established a 100-year to SPF ratio of 0.58 as appropriate for the drainage area of the Santa Ana River below Prado Dam. The SPF subarea hydrographs were reduced by this ratio and then routed and combined to generate the mainstem local 100-year hydrograph. For the analysis in this report, the peak discharge on the side drain was adjusted in time to occur simultaneously with peak discharges on the mainstem. This condition of simultaneous hydrographs actually provides for a contemporaneous peak discharge in the mainstem of an approximate 15- to 20-year event based on the discharge-frequency relationship of the mainstem. A nominal outflow from Prado Dam of 5,000 ft^3/s was added to the hydrograph as baseflow. The 100-year hydrographs for each subarea were determined as the 0.58 ratio of the SPF determined from a storm centered over each subarea. If more than one drainage pipe was located in a subarea, the discharges were distributed to each individual drain as a percentage of the estimated individual drainage area to the larger subarea drainage area. The Santa Ana River mainstem contemporaneous hydrograph upstream of Katella Avenue Bridge and the subarea "UU" 100-year hydrograph (pl. 7-74) is shown as a typical example.

Oak Street Drain Side Drainage

12-05 Peak discharges for Oak Street Drain side drains (table 7-37) were calculated for the 25-year flood frequency level as determined from peak discharge-frequency curves previously presented. The SPF hydrographs were reduced by the ratio of 25-year peak discharge to SPF peak discharge.

Prado Dikes

12-06 There are four recommended interior dikes, and two auxiliary dikes within Prado Reservoir. The four interior dikes are proposed for the wastewater treatment plant owned by the city of Corona, the Alcoa aluminum plant, the Corona National Housing Tract, and the California Institute for Women. Auxiliary dikes are proposed for locations north of the A.T. and S.F. (Santa Fe) Railroad, and along the Corona Expressway (pl. 7-73). The auxiliary dike, which will be aligned parallel to the railroad tracks, was also included in the interior drainage study. The Corona Expressway dike will not require drainage structures due to its location on the edge of Prado Reservoir. Runoff from the west side of

the future expressway will drain into a local storm drain system along the southbound lane. Flood hydrographs were generated using the SPF general storm and SPF local storm for each of the five subareas to establish peak design discharges and volumes (table 7-38). The 100-year flood from a local storm was taken as a ratio of 0.58 of the local SPF. For this interior drainage analysis, the local storm was considered to be imbedded in the larger general storm, such that the maximum rainfall intensities for the interior areas was coincident with the maximum rainfall intensities of the general storm runoff centered above Prado Dam. Thus, the coincident Prado Dam stage hydrograph was determined by a reservoir routing of the general storm hydrograph. A typical relationship of local storm hydrograph, general storm hydrograph, and reservoir stage is shown on plate 7-75 for subarea C. The required drainage pipe size and the ponding area elevation was determined by routing the interior subarea hydrograph with the coincident Prado reservoir stage hydrograph (table 7-39). The hydraulic analysis is presented in Volume 2, Section V of the Phase II GDM.

Santiago Creek Side Drainage

12-07 Peak discharge for the Santiago Creek side drains (table 7-40) were calculated at the 100-year flood frequency level as determined from peak discharge-frequency curves shown on plate 7-60. The SPF hydrograph of each subarea was reduced by the ratio of 0.58 to SPF peak discharge. The discharges were distributed to each individual drain as a percentage of the estimated individual drainage area to the larger subarea drainage area.

Residual Flooding

12-08 The existing overflow area in Orange County from the Santa Ana River mainstem design flood is estimated at 100,000 acres. The recommended plan of improvement will remove most of this flood threat. Some flooding will continue to occur in the areas removed from the mainstem flood threat by streams originating in Orange County downstream of Prado Dam. A number of these streams have been, or are being investigated under Santa Ana River Basin and Orange County Interim 3 studies. During floods of the same approximate frequency as the SAR design flood (190-year), localized flooding will occur on streams such as Talbert Valley, East Garden Grove-Wintersburg, Brea Creek, Fullerton Creek, Carbon Creek, and others (pl. 7-76). In addition, localized flooding will occur at the project channel "line-of-protection" for floods greater than the interior area design flood (generally 100-year). The location of flooding was identified for a local SPF. The identified locations are addressed in Volume 3, Section 4 of the Phase II GDM.

XIII. RISK ANALYSIS

"Exceedance frequency" is the percent chance that a specified flood magnitude will be equalled in any given year. "Risk" expresses the likelihood (percent chance) that one or more floods may exceed the design flow within a specified number of years. This section addresses the risk of the design flood being exceeded in an amount of time called the project life. The project life is defined as the number of years a project is intended to last with proper maintenance, and was considered to be 100 years for all of the recommended project elements. The risk of the recommended project elements (1.0 percent to 0.29 percent annual exceedance frequency levels of protection) being exceeded (table 7-41) was based on ETL 1110-2-274.

XIV. ADEQUACY OF ESTIMATES

Standard Project Flood Peak Discharges

14-01 The standard project flood, as developed, is of a magnitude that would be exceeded only on rare occasions. The adequacy of the standard project flood peak discharges on the Santa Ana River and its tributaries is indicated by comparison of those discharges with the enveloping curves of peak discharges (pl. 7-77).

SEVEN OAKS DAM

14-02 The standard project flood at Seven Oaks Dam (82,000 ft^3/s) is about 1.5 times as large as the March 1938 flood peak (52,300 ft^3/s), which is the largest recorded flood for the gauge "Santa Ana River near Mentone".

PRADO DAM

14-03 The SPF estimated peak discharge at Prado Dam, is over three times as large as the March 1938 flood peak of 100,000 ft^3/s, the largest recorded flood at a point about 2.5 miles downstream from Prado Dam. The flood of January, 1862 was documented in written accounts by early residents of the Santa Ana River basin as a flood of tremendous proportions. No recorded information is available, although estimates of peak discharge for this flood indicate a flow rate of approximately 317,000 ft^3/s at Riverside Narrows.

MILL CREEK

14-04 The Mill Creek standard project flood (33,000 ft^3/s) is nearly equal to the highest estimated discharge of 35,400 ft^3/s (slope area from flood marks) from the January 1969 flood at the "Mill Creek at Yucaipa" gauging station. However, caution should be exercised with the comparison of these two discharges. The estimated flow of 35,400 ft^3/s was influenced by debris load and a bridge constriction. The estimated flow a mile downstream at the Mill Creek levees for the same event was

18,000 ft^3/s. A standard project flood peak discharge resulting from the largest storm of record in the region, transposed over the area at a time when ground conditions were conducive to a high rate of runoff is considered satisfactory for a flood that would be exceeded only on rare occasions.

100-Year Design Flood Peak Discharges

OAK STREET DRAIN

14-05 The adequacy of the 100-year design flood peak discharges (table 7-19) are indicated by a comparison with enveloping curves of recorded discharges of past floods in southern California (pl. 7-77). The values lie somewhat below the enveloping curve but are reasonable estimates based on the location of the drainage basin, which is on the backside of the Santa Ana Mountains. The 100-year design values exceed the 100-year discharge values presently used for flood insurance purposes in part because future conditions of urbanization was used.

SANTIAGO CREEK

14-06 The adequacy of the 100-year design flood peak discharge at Villa Park Dam is indicated by a comparison with the enveloping curves of recorded discharges of past floods in southern California (pl. 7-77). The 100-year flood peak and volume exceeds the largest recorded flood event (22-25 February 1969) since at least 1921.

Sediment Allowance

PRADO DAM

14-07 The 100-year sediment allowance for Prado Dam is based on actual accumulation in Prado Dam over a 39-year period from 1941 to 1980.

SEVEN OAKS DAM

14-08 The 100-year sediment allowance for Seven Oaks Dam is reasonable because data used to determine the sediment estimate were obtained from geomorphically similar areas within the San Gabriel Mountains.

Table 7-1. Santa Ana River Mainstem Precipitation Stations.

No.*	Station	Elevation (feet)	Geographic Coordinates latitude (degrees-minutes)	Geographic Coordinates longitude (degrees-minutes)	Period of record	NAP (inches)	Type	Authority
1.	Anza	3,915	33-33	116-40	1947-	12.70	NR	NWS
2.	Arrowhead Springs	2,000	34-11	117-16	1909-1925	35.53	NR	NWS
3.	Banning	2,380	33-56	116-53	1899-1944	15.39	NR	RCFCWCD
4.	Barneson Park	575	33-56	117-51	1941-1967	14.72	NR	NWS
5.	Beaumont 1-E	2,600	33-56	116-58	1939-	17.12	Both	NWS
6.	Beaumont Pumping Plant	3,045	33-59	116-58	1911-	20.28	NR	NWS
7.	Bennet Ranch	1,850	34-10	117-28	1918-1953	25.97	NR	NWS
8.	Big Bear Lake Dam	6,815	34-14	116-58	1892-	35.54	Both	NWS
9.	Big Dalton Dam	1,575	34-10	117-49	1930-1981	25.13	NR	NWS
10.	Big Pines Park	6,860	34-23	117-41	1926-	25.09	Both	NWS
11.	Brea Dam	275	33-53	117-56	1941-	12.66	R	NWS
12.	Cabazon	1,815	33-55	116-47	1939-1974	12.57	NR	NWS
13.	Camp Angelus	5,770	34-09	116-59	1939-	31.77	R	NWS
14.	Carbon Canyon Workman	1,175	33-57	117-48	1951-	17.99	R	NWS
15.	Corona	710	33-53	117-34	1908-	12.19	NR	NWS
16.	Crestline Fire Station	4,530	34-14	117-17	1965-	40.25	NR	NWS
17.	Deckers Ranch	5,550	33-48	116-45	1921-1941	33.34	NR	NWS
18.	Diamond Bar Horse Camp	748	33-59	117-50	1930-	16.28	R	NWS
19.	East Pine Flat	5,740	34-20	117-50	1931-1959	35.60	NR	NWS
20.	El Modena	464	33-48	117-47	1938-	13.87	R	NWS
21.	Etiwanda 1N	1,390	34-08	117-32	1937-	17.09	Both	NWS
22.	Fontana Union W.C.	1,280	34-06	117-26	1923-	17.60	NR	NWS
23.	Fontana 5N	1,972	34-11	117-27	1953-	25.43	Both	NWS
24.	Fontana Kaiser	1,090	34-05	117-30	1950-	15.44	NR	NWS
25.	Fullerton Dam	340	33-54	117-53	1948-	13.00	R	NWS
26.	Fullerton Hillcrest	340	33-52	117-54	1934-	33.34	NR	NWS

Note: The following abbreviations appear in this table.
NAP, Normal Annual Precipitation; NR, non-recording; R, recording; LACFCD, Los Angeles County Flood Control District; NWS, National Weather Service; RCFCWCD, Riverside County Flood Control and Water Conservation District.
See Plate 7-12 for locations of stations.

Table 7-1. (Continued)

No.*	Station	Elevation (feet)	Geographic Coordinates latitude (degrees-minutes)	longitude (degrees-minutes	Period of record	NAP (inches)	Type	Authority
27.	Hemet	1,630	33-45	116-57	1941-	11.53	NR	NWS
28.	Hemet Reservoir	4,355	33-40	1161-40	1939-1961	17.02	Both	NWS
29.	Hurley Flat	3,600	33-52	116-47	1919-1947	20.04	NR	RCFCWCD
30.	Idyllwild Ranger Station	5,397	33-45	116-43	1943-	23.38	Both	NWS
31.	Lake Arrowhead	5,250	34-15	117-12	1891-	40.25	NR	NWS
32.	Live Oak Canyon	1,510	34-08	117-45	1939-1974	18.83	Both	LACFCD
33.	Lytle Creek @ Foothill	1,160	34-07	117-20	1946-	18.10	R	NWS
34.	Lytle Creek Powerhouse	2,225	34-12	117-27	1905-	32.36	R	NWS
35.	Lytle Creek Fire Sation	2,760	34-14	117-29	1930-	32.79	Both	NWS
36.	March AFB	1,537	33-54	117-15	1928-	10.28	R	NWS
37.	Mentone	1,765	34-04	117-07	1952-	15.14	NR	NWS
38.	Mill Creek	2,940	34-05	117-02	1903-1967	21.42	NR	NWS
39.	Mill Creek Intake	4,958	34-05	116-56	1930-	27.00	R	NWS
40.	Mt. Baldy FC 85G	4,275	34-14	117-40	1916-1976	31.81	Both	NWS
41.	Olinda	490	33-55	117-51	1941-1967	13.84	NR	NWS
42.	Brea Orange County Res.	660	33-56	117-53	1943-	13.45	NR	NWS
43.	Pacific Colony	690	34-03	117-49	1920-1954	15.30	R	NWS
44.	Pomona	855	34-04	117-46	1913-	17.43	NR	NWS
45.	Prado Dam	560	33-53	117-38	1940-	12.51	R	NWS
46.	Raywood Flats	6,620	34-03	116-49	1931-1961	33.28	NR	NWS
47.	Redlands	1,318	34-03	117-11	1931-	14.03	NR	NWS
48.	Running Springs 1N	5,965	34-12	117-05	1934-	35.79	R	NWS
49.	San Antonio Cyn. Mouth	2,394	34-10	117-41	1917-	25.43	NR	NWS
50.	San Bernardino Hospital	1,125	34-08	117-16	1870-	16.90	NR	NWS
51.	San Dimas FC 95	955	34-06	117-48	1931-	18.44	NR	NWS
52.	San Dimas Tanbark	2,745	34-12	117-46	1929-1981	25.06	R	NWS

Note: The following abbreviations appear in this table.
NAP, Normal Annual Precipitation; NR, non-recording; R, recording; LACFCD, Los Angeles County Flood Control District; NWS, National Weather Service; RCFCWCD, Riverside County Flood Control and Water Conservation District.
See Plate 7-12 for locations of stations.

Table 7-1. (Continued)

No.*	Station	Elevation (feet)	Geographic Coordinates latitude (degrees-minutes)	longitude (degrees-minutes)	Period of record	NAP (inches)	Type	Authority
53.	San Gabriel Cyn.	744	34-09	117-54	1917-	20.73	Both	NWS
54.	San Gabriel Dam	1,481	34-12	117-52	1938-	27.03	R	NWS
55.	San Jacinto RS	1,560	33-47	116-58	1886-	12.66	Both	NWS
56.	Santa Ana River PH1	2,765	34-09	117-04	1904-	16.08	NR	NWS
57.	Santa Ana River PH3	1,980	34-06	117-07	1939-1966	25.09	R	NWS
58.	Santiago Dam	860	33-47	117-43	1938-	14.50	R	NWS
59.	Seven Oaks	5,075	34-11	116-57	1931-1955	26.16	NR	NWS
60.	Shell Absorption P1	680	33-57	117-54	1948-1967	16.02	NR	NWS
61.	Snow Creek	1,280	33-53	116-41	1919-1957	11.44	NR	NWS
62.	Squirrel Inn 2	5,723	34-14	117-14	1929-1971	40.65	NR	NWS
63.	Table Mountain	7,500	34-23	117-41	1928-1962	15.35	NR	NWS
64.	Trabuco Cyn.	900	33-39	117-36	1939	19.39	R	NWS
65.	Upland	1,840	34-08	117-41	1903-1979	21.16	Both	NWS
66.	Walnut Patrol Sta.	488	34-00	117-52	1942-	15.25	NR	NWS
67.	Winchester	1,470	33-42	117-05	1941-1971	10.79	R	NWS
68.	Yorba Linda	405	33-54	117-49	1912-	13.25	NR	NWS

Note: The following abbreviations appear in this table.
NAP, Normal Annual Precipitation; NR, non-recording; R, recording; LACFCD, Los Angeles County Flood Control District; NWS, National Weather Service; RCFCWCD, Riverside County Flood Control and Water Conservation District.
See Plate 7-12 for locations of stations.

Table 7-2. Santa Ana River Mainstem Stream Gauging Stations.

No.	Station	Drainage area (mi^2)	Geographic Coordinates: Latitude (deg & min)	Geographic Coordinates: Longitude (deg & min)	Period of records: Recording	Period of records: Non-Recording	Maximum discharge of record, Peak: Discharge (ft^3/s)	Peak: Date	Mean daily: Discharge (ft^3/s)	Mean daily: Date
1.	Santa Ana River near Mentone(b)	177.0	34-07	117-06	1917-	1896-1917	52,300	Mar 2, 1938	15,500	Mar 2, 1938
2.	Santa Ana River at Riverside Narrows near Arlington(b)	818.0	33-58	117-28	1927-72		100,000	Do.	N/A	N/A
							320,000	Jan 22, 1862	N/A	N/A
3.	Santa Ana River at E Street near				1939-54					
	San Bernardino(b)	500.0	34-04	117-18	1966-		28,000	Feb 25, 1969	14,800	Feb 25, 1969
4.	Santa Ana River below Prado Dam(b)	2,255.0	33-53	117-39	1940-		7,440	Feb 21, 1980	6,440	Feb 23, 1980
5.	Santa Ana River near Prado Dam(b)	2,244.0	33-52	117-40	1919-42		100,000	Mar 3, 1938	28,000	Mar 3, 1938
6.	Mill Creek near Mentone	46.3	34-05	117-07	1939-65		1,500	Dec 23, 1945	170	Dec 24, 1941
7.	Mill Creek near Yucaipa	38.1	34-05	117-02	1919-38		35,400	Jan 25, 1969	6,300	Mar 2, 1938
					1947-					
8.	Plunge Creek near East Highlands	16.9	34-07	117-08	1919-		5,340	Mar 2, 1938	N/A	N/A
9.	City Creek near Highland	19.6	34-09	117-11	1919-		7,000	Feb 25, 1969	3,360	Feb 25, 1969
10.	Santa Ana River at Waterman Ave. at				1954-70					
	San Bernardino(b)	322.0	34-04	117-17	1975-82	1928-37	75,700	Mar 2, 1938	N/A	N/A
11.	San Timoteo Creek near Redlands	118.0	34-02	117-12	1926-68		7,460	Do.	1,860	Mar 2, 1938
					1973-79					
12.	San Timoteo Creek near Loma Linda	125.0	34-04	117-17	1954-75		15,000	Feb 25, 1969	N/A	N/A
					1979-					
13.	East Twin Creek near Arrowhead Springs	8.8	34-11	117-16	1919-		3,710	Jan 29, 1980	N/A	N/A
14.	Waterman Canyon Creek near Arrowhead Springs	4.7	34-12	117-16	1919-	1911-14	2,350	Mar 2, 1938	478	Mar 2, 1938
15.	Lytle Creek near Fontana	46.3	34-13	117-27	1918-		35,900	Jan 25, 1969	8,960	Do.
16.	Cajon Creek near Keenbrook	40.6	34-16	117-28	1919-		14,500	Mar 2, 1938	3,800	Do.
17.	Lone Pine Creek near Keenbrook	15.1	34-16	117-28	1919-		6,180	Do.	1,480	Do.
18.	Devil Canyon near San Bernardino	5.5	34-12	117-20	1919-	1911-14	3,720	Jan 25, 1969	556	Jan 25, 1969
19.	Santa Ana River at Imperial Highway	2,306.0	33-52	117-47	1941-81		6,000	Feb 28, 1969	N/A	N/A
							100,000	Mar 2, 1938	N/A	N/A
20.	Day Creek near Etiwanda	4.6	34-11	117-32	1927-72		9,450	Jan 25, 1969	4,070	Jan 25, 1969
21.	San Jacinto River				1920-37	1937-1948				
	near San Jacinto	141.0	33-44	116-50	1948-		45,000	Feb 16, 1927	N/A	N/A
22.	Bautista Creek near Hemet	39.4	33-42	116-51	1947-69		1,440	Apr 3, 1958	N/A	N/A
23.	San Jacinto River near Elsinore	723.0	33-40	117-18	1921-	1916-21	16,000	Feb 17, 1927	N/A	
24.	Temescal Creek near Corona	164.0	33-50	117-31	1927-80		14,900	Mar 2, 1938	3,460	Mar 2, 1938
25.	San Antonio Creek near Claremont	16.5	34-13	117-40	1917-72	1901-17	21,400	Do.	4,430	Jan 25, 1969
26.	Cucamonga Creek near Upland	10.1	34-10	117-38	1928-75	1927-28	14,100	Jan 25, 1969	4,050	Jan 25, 1969
27.	Santiago Creek at Modjeska	12.5	33-43	117-38	1919-61		6,520	Feb 25, 1969	3,590	Feb 24, 1969
28.	Santiago Creek near Villa Park	83.8	33-49	117-47	1920-63		11,000	Feb 16, 1927	7,000	Feb 16, 1927

Table 7-2. Continued.

No.	Station	Drainage area (mi^2)	Geographic Coordinate: Latitude (deg & min)	Longitude (deg & min)	Period of records: Recording	Non-Recording	Maximum discharge of record: Peak: Discharge (ft^3/s)	Peak: Date	Mean daily: Discharge (ft^3/s)	Mean daily: Date
29.	Santiago Creek at Santa Ana............	98.6	33-46	117-53	1928-		6,600	Feb 26, 1969	4,270	Feb 25, 1969
30.	Santa Ana River at Santa Ana(b).......	2,447.0	33-45	117-55	1923-76		46,300	Mar 3, 1938	20,300	Mar 3, 1938
31.	Carbon Creek at Olinda................	20.0	33-53	117-51	1930-38		1,760	Mar 2, 1938	N/A	N/A
	Carbon Creek near Yorba Linda.........	20.4			1950-61		935	Apr 3, 1958	180	Apr 3, 1958
	Carbon Creek at Carbon Canyon Dam.....	19.5	33-55	117-50	1961-		1,050	Jan 25, 1969	300	Jan 25, 1969
32.	Brea Creek at Fullerton...............	26.4	33-52	117-56	1932-40		1,970	Mar 2, 1938	944	Mar 2, 1938
	Brea Creek at Brea Reservoir..........	22.0			1941-72		2,000	Mar 14, 1941	N/A	N/A
33.	Fullerton Creek at Fullerton..........	6.2	33-52	117-54	1936-40		900	Mar 2, 1938	N/A	N/A
	Fullerton Creek at Fullerton Dam......	5.1			1941-		3,800	Mar 14, 1941	N/A	N/A
34.	Little San Gorgonio Creek near Beaumont.............................	3.2	34-02	116-57	1948-		11,000	Feb 25, 1969	1,180	Feb 25, 1969
35.	Lytle Creek at Colton.................	172.0	34-05	117-18	1957-		17,500	Mar 4, 1978	5,040	Jan 25, 1969
36.	Reche Canyon at Barton Road near Colton...............................	11.2	34-03	117-17	1928-75		1,175	Feb 25, 1969	N/A	N/A
37.	Santa Ana River at MWD Crossing near Arlington, CA (b)....................	854.0	33-48	117-27	1970-		19,500	Mar 4, 1978	6,800	Mar 4, 1978
38.	Handy Creek (Alameda Storm Channel) Orange, CA............................	3.2	33-48	117-48	1938-		1,220	Feb 22, 1944	4	Mar 4, 1978
39.	Santa Ana River at Prado Park near Corona, CA (b)........................	1,010.0	33-56	117-36	1971-80		30,000	Mar 4, 1978	12,000	Mar 4, 1978

Note: Data are from records published in the U.S. Geological Survey Water Supply Papers. N/A indicates data are not available.

a. See plate 7-13 for location of gauging stations.

b. Areas given for points on the Santa Ana exclude 32 square miles tributary to Baldwin Lake.

c. Data presented is outside period of record.

Table 7-3. Subarea Drainage Characteristics, Santa Ana River Basin.

Subarea Designation[a]	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Values Present Condition	Basin n-Values Future Condition	Lag[b] (hr)	Percent Impervious Present Condition	Percent Impervious Future Condition	S-Graph
A1	38	5.1	3.1	365.0	.060	.060	1.66	0	2	Mountain
A2	91	18.9	9.2	450.0	.060	.060	3.20	0	2	Mountain
A3	31	9.8	5.3	628.0	.060	.060	1.90	0	2	Mountain
A4	17	7.4	3.9	594.0	.060	.060	1.53	0	2	Mountain
B	43	13.0	6.0	565.0	.060	.060	2.26	0	2	Mountain
C1	9	8.2	3.8	493.0	.050	.050	1.36	5	15	Mountain
C2	13	3.9	2.0	474.0	.050	.040	.65	5	15	Mountain
D	11	5.5	2.8	418.0	.050	.040	.86	5	15	Valley
D1	20	7.6	4.8	609.0	.050	.050	1.40	0	2	Mountain
D2	17	7.5	4.6	607.0	.050	.050	1.36	0	2	Mountain
E1	36	13.3	7.0	140.0	.025	.020	1.05	25	40	Valley
E2	39	12.0	6.0	535.0	.035	.030	1.11	20	30	Valley
E3	59	18.6	6.9	374.0	.040	.035	1.72	5	10	Valley
E4	30	11.6	7.1	78.0	.040	.035	1.96	5	10	Valley
F1	17	7.6	5.1	643.0	.050	.050	1.41	0	2	Mountain
F2	29	11.0	6.9	264.0	.025	.020	.86	40	50	Valley
G1	73	19.6	9.7	255.0	.050	.040	2.50	0	2	Mountain
G2	52	16.0	7.6	468.0	.050	.050	2.31	0	2	Mountain
H1	19	7.8	3.9	516.0	.045	.045	1.21	0	2	Mountain
H2	48	13.5	7.0	184.0	.020	.020	1.00	40	50	Valley
I	62	21.0	11.0	63.0	.020	.020	1.73	40	50	Valley
J	31	16.7	7.6	127.0	.035	.030	1.81	15	30	Valley
L	39	17.8	10.4	57.0	.030	.025	2.02	15	30	Valley
M	136	25.0	12.1	331.0	.030	.020	1.40	30	40	Valley
N	38	14.6	9.1	47.0	.030	.020	1.48	15	25	Valley
O	79	21.6	10.4	382.0	.030	.020	1.21	25	40	Valley
P	27	10.3	5.9	769.0	.050	.050	1.62	0	2	Mountain
Q	107	20.7	11.8	142.0	.030	.015	1.13	30	50	Valley

Table 7-3. (Continued).

Subarea Designation[a]	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Values Present Condition	Basin n-Values Future Condition	Lag[b] (hr)	Percent Impervious Present Condition	Percent Impervious Future Condition	S-Graph
R1	44	7.2	2.5	41.0	.050	.040	1.42	5	5	Valley
R2	146	27.3	11.8	25.0	.035	.025	2.92	5	30	Valley
R3	187	23.6	11.3	58.0	.040	.030	2.78	10	30	Valley
R4	138	27.0	11.9	117.0	.040	.035	3.05	5	10	Valley
S	193	36.2	13.6	149.0	.050	.040	3.91	0	2	Mountain
R5	245	24.4	12.2	72.0	.045	.040	3.71	5	10	Mountain
S1	45	16.7	8.0	61.0	.037	.030	2.12	5	20	Valley
S2	36	7.9	2.7	50.0	.035	.030	1.10	5	10	Valley

a. See plate 7-1 for subarea location.
b. Future Conditions.

Table 7-4. Subarea Drainage Characteristic, Oak Street Drain.

Subarea*	Drainage area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Value Present Condition	Basin n-Value Future Condition	Percent Impervoius Present Condition	Percent Impervoius Future Condition	S-Graph
A	1.50	3.10	1.71	516	.050	.050	5	5	Mountain
B	6.13	3.71	1.63	590	.050	.050	5	5	Mountain
C	1.24	1.86	0.95	806	.040	.040	5	5	Mountain
D	1.27	1.99	0.99	202	.035	.025	10	40	Valley
E1	0.63	2.00	1.06	220	.050	.025	5	35	Valley
E2	0.62	2.03	1.04	220	.050	.030	5	25	Valley
E3	0.26	1.26	0.75	112	.025	.020	25	45	Valley
E4	0.15	1.27	0.62	118	.025	.020	25	45	Valley
F	0.15	0.90	0.52	115	.025	.020	25	45	Valley
G	2.97	4.79	1.76	185	.025	.020	25	45	Valley

* See plate 7-4 for location.

Table 7-5. Subarea Drainage Characteristics, Santiago Creek.

Sub-area*	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Value Future Condition	Percent Impervious Future Condition	S-Graph
A	63.40	15.80	6.50	305	.040	4	Santa Margarita
B	20.40	10.50	5.60	210	.040	4	Santa Margarita
C	2.90	3.60	1.81	185	.020	25	Valley
D	4.70	6.30	3.40	147	.020	25	Valley
D1	1.23	1.94	0.78	156	.020	40	Valley
E	1.96	3.26	1.81	172	.020	40	Valley
F	2.39	2.52	1.19	125	.020	45	Valley
G	4.04	3.26	0.98	35	.020	55	Valley
H	1.68	2.27	1.21	31	.020	55	Valley

*See Plate 7-5 for location.

Table 7-6. Design Flood Peak Discharges at Locations Along the Lower Santa Ana River.

Location	Design Flood Peak Discharge (ft^3/s)
Prado Dam Outflow	30,000
Downstream of:	
Wardlow Canyon	31,000
Weir Canyon Road	37,000
Imperial Highway	38,000
Carbon Canyon Diversion Creek	40,000
Santa Ana Freeway	42,000
Santiago Creek	46,000
Hamilton Avenue	47,000
Pacific Ocean	47,000

Table 7-7. Subarea Drainage Characteristics, Lower Santa Ana River Between Prado Dam and Weir Canyon Road.

Subarea Designation[(1)]	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Value Present Condition	Basin n-Value Future Condition	Lag (Hours)	Percent Impervious Present Condition	Percent Impervious Future Condition	S-Graph
XA1	3.10	5.70	2.80	432	.050	.040	0.87	5	10	Av. Fullerton & San Jose
XA2	0.40	1.00	0.60	210	.050	.040	0.29	10	10	Av. Fullerton & San Jose
XA3	2.10	3.80	1.98	350	.060	.040	0.68	5	10	Av. Fullerton & San Jose
XB1	10.60	6.70	3.80	210	.055	.050	0.15	5	10	Av. Fullerton & San Jose
XB2	1.20	2.00	0.98	331	.045	.040	0.41	5	10	Av. Fullerton & San Jose
XB3	1.00	2.70	1.40	415	.055	.040	0.51	10	10	Av. Fullerton & San Jose
XC1	0.10	0.47	0.31	157	.040	.035	0.15	20	25	Av. Fullerton & San Jose
XC	0.65	1.69	0.85	1340	.040	.045	0.32	10	10	Av. Fullerton & San Jose
XA	2.13	2.94	1.74	823	.040	.045	0.50	5	10	Av. Fullerton & San Jose
XB	0.54	1.50	0.78	1090	.040	.050	0.30	5	10	Av. Fullerton & San Jose
XD	0.75	1.99	0.98	331	.040	.045	0.41	5	10	Av. Fullerton & San Jose
XE	0.77	1.99	1.07	301	.045	.045	0.43	5	10	Av. Fullerton & San Jose
XF	5.28	3.49	2.12	556	.045	.045	0.62	5	10	Av. Fullerton & San Jose
XH	2.40	3.48	1.39	305	.040	.045	0.59	5	10	Av. Fullerton & San Jose
XG	1.16	3.12	1.59	234	.040	.045	0.63	5	10	Av. Fullerton & San Jose
XI	0.74	1.85	1.15	356	.045	.045	0.42	10	10	Av. Fullerton & San Jose
XJ	1.11	2.84	1.67	398	.050	.045	0.55	10	15	Av. Fullerton & San Jose
XK	1.72	2.20	1.12	480	.050	.045	0.42	10	15	Av. Fullerton & San Jose

(1) See plates 7-7 through 7-10 for locations.

Table 7-8. Subarea Drainage Characteristics of Lower Santa Ana River Between Weir Canyon Road and Pacific Ocean.

Subarea Designation (1)	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Value		Lag (Hours)	Percent Impervious		S-Graph
					Present Condition	Future Condition		Present Condition	Future Condition	
A	0.84	2.27	1.01	405	.046	.035	0.37	5	10	Av. Fullerton & San Jose
B	1.89	2.35	0.91	451	.050	.040	0.40	5	10	Av. Fullerton & San Jose
C1	2.19	1.95	0.80	605	.060	.040	0.34	5	10	Av. Fullerton & San Jose
C2	1.55	3.74	1.83	336	.055	.040	0.66	5	10	Av. Fullerton & San Jose
C3	0.67	2.19	1.14	232	.045	.040	0.42	10	15	Av. Fullerton & San Jose
D	1.22	2.72	1.43	283	.055	.040	0.55	5	10	Valley
E	0.55	1.26	0.90	253	.040	.030	0.26	20	25	Valley
ED	0.10	0.65	0.20	8	.040	.030	0.22	20	25	Valley
G1	0.59	1.50	0.84	360	.040	.030	0.26	20	25	Valley
FG	0.35	0.53	0.30	20	.040	.030	0.20	15	20	Valley
G2	0.79	1.29	0.76	333	.045	.035	0.28	15	20	Valley
F	0.87	1.64	0.67	134	.045	.035	0.34	15	20	Valley
H	2.54	3.62	2.05	251	.040	.035	0.63	10	15	Valley
I	0.35	0.99	0.69	252	.040	.030	0.22	20	25	Valley

(1) See plates 7-7 through 7-10 for locations.

Table 7-8. (Continued)

Subarea Designation (1)	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Value Present Condition	Basin n-Value Future Condition	Lag (Hours)	Percent Impervious Present Condition	Percent Impervious Future Condition	S-Graph
IJ	0.10	0.52	0.30	10	.040	.030	0.23	20	25	Valley
J	0.57	1.72	0.92	459	.045	.035	0.31	15	20	Valley
K1	1.98	2.76	1.60	304	.055	.040	0.57	10	15	Av. Fullerton & San Jose
K2	0.74	1.53	1.07	215	.045	.035	0.37	15	25	Valley
L1	0.72	1.56	0.93	500	.045	.033	0.28	20	25	Valley
L2	0.61	1.48	0.78	432	.045	.033	0.26	20	25	Valley
L3	0.48	1.45	0.92	413	.045	.030	0.26	20	25	Valley
L4	0.44	1.53	0.75	412	.045	.030	0.24	25	30	Valley
NL	0.35	1.01	0.50	15	.040	.030	0.33	20	25	Valley
L5	0.63	1.33	0.76	466	.045	.030	0.22	25	30	Valley
L6	0.50	1.11	0.60	423	.040	.030	0.20	30	35	Valley
NL6	0.32	0.85	0.40	12	.040	.025	0.25	10	15	Valley
L7	0.51	1.53	0.89	114	.035	.025	0.27	35	40	Valley

(1) See plates 7-7 through 7-10 for locations.

Table 7-8. (Continued)

Subarea Designation (1)	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Value Present Condition	Basin n-Value Future Condition	Lag (Hours)	Percent Impervious Present Condition	Percent Impervious Future Condition	S-Graph
N+N6+N2	18.70			(CARBON CANYON DIVERSION CHANNEL)						Av. Fullerton & San Jose
OOP1	0.03	0.18	0.10	12	.040	.030	0.13	30	35	Valley
OOP2	0.07	0.43	0.20	20	.040	.030	0.16	30	35	Valley
OPP	0.01	0.44	0.25	10	.040	.030	0.19	30	35	Valley
P	1.62	2.88	1.69	177	.040	.030	0.49	35	40	Valley
O	2.03	3.88	2.40	15	.040	.030	1.00	40	50	Valley
Q	0.32	1.16	0.60	13	.040	.030	0.39	35	40	Valley
S	0.39	1.44	0.66	10	.040	.030	0.46	30	35	Valley
UU	0.15	0.68	0.30	15	.040	.035	0.27	20	25	Valley
R	4.90	4.86	2.91	152	.035	.025	0.63	35	40	Valley
TT	0.29	1.37	0.56	15	.040	.035	0.45	20	25	Valley
T	1.53	3.51	1.51	31	.040	.030	0.71	40	45	Valley
U	2.61	4.48	2.70	14	.040	.030	1.12	40	45	Valley
V	0.56	1.49	0.81	26	.035	.030	0.42	40	45	Valley
UV	0.16	0.84	0.41	13	.045	.040	0.39	30	34	Valley

(1) See plates 7-7 through 7-10 for locations.

Table 7-8. (Continued)

Subarea Designa-tion (1)	Drainage Area (mi^2)	L (mi)	Lca (mi)	Slope (ft/mi)	Basin n-Value Present Condition	Basin n-Value Future Condition	Lag (Hours)	Percent Impervious Present Condition	Percent Impervious Future Condition	S-Graph
W	102.50		----	----	(SANTIAGO CREEK)		----		--	Santa Margarita & Valley
WV1	0.12	0.49	0.24	12	.035	.025	0.17	40	45	Valley
WV2	0.64	1.59	0.73	16	.035	.025	0.37	40	45	Valley
WV4	0.04	0.19	0.10	30	.040	.035	0.10	35	40	Valley
WV5	0.11	0.40	0.20	15	.040	.035	0.19	30	35	Valley
WV6	0.08	0.48	0.29	10	.040	.035	0.26	30	45	Valley
WV	0.34	1.56	0.84	11	.040	.035	0.48	30	35	Valley
WV3	1.38	3.68	2.10	20	.030	.025	0.74	40	45	Valley
WVX	0.03	0.18	0.10	25	.035	.030	0.08	30	35	Valley
X1	0.39	1.99	1.09	10	.035	.030	0.62	40	45	Valley
X3	0.40	0.92	0.42	4.22	.035	.030	0.38	40	45	Valley
X2	0.78	1.26	0.58	2.38	.035	.030	0.54	40	45	Valley
GV3+GV4+GV5	10.50	----	----	(GREENVILLE-BANNING CHANNEL)				--		Valley

(1) See plates 7-7 through 7-10 for locations.

Table 7-9. Santa Ana River Mainstem Discharge-Frequency Values. (Present Conditions)

Location	200-YR	100-YR	50-YR	25-YR	10-YR	5-YR	2-YR
	Frequency of Peak Discharge (in ft^3/s)						
at Seven Oaks Dam (D.A. = 177 mi^2)							
Inflow							
w/o project and w/project	88,000	58,000	34,000	20,500	8,800	4,300	1,100
Outflow							
w/o project			same as inflow				
w/project	6,400	5,000	3,800	2,900	500	500	400
D/S of Mill Creek (D.A. = 242 mi^2)							
w/o project	120,000	75,000	45,000	26,000	11,700	5,600	1,400
w/project	37,000	25,000	15,500	9,300	4,300	2,050	760
D/S of City Creek (D.A. = 290 mi^2)							
w/o project	125,000	80,000	48,000	28,000	12,500	5,800	1,400
w/project	49,000	32,000	20,000	12,000	5,400	2,600	800
at E Street (D.A. = 500 mi^2)							
w/o project	165,000	105,000	60,000	33,000	13,500	6,000	1,400
w/project	100,000	67,000	39,000	22,000	9,000	4,000	920
at Riverside Narrows (D.A. = 824 mi^2)							
w/o project	265,000	175,000	102,000	57,000	23,000	9,500	1,600
w/project	205,000	130,000	80,000	45,000	18,000	7,600	1,400
at Prado Dam (D.A. = 2255 mi^2)							
Inflow							
w/o project	360,000	230,000	132,000	72,000	28,000	11,500	2,800
w/project	300,000	195,000	110,000	60,000	23,000	9,500	2,300
Outflow							
w/o project	160,000	50,000	6,400	5,600	3,100	1,650	600
w/project	30,000	30,000	20,000	12,000	3,700	1,900	600
at Imperial Hwy (D.A. = 2306 mi^2)							
w/o project	150,000	50,000	7,500	6,000	3,500	1,700	700
w/project	36,000	35,000	24,000	12,500	4,700	2,500	800
at Santa Ana (D.A. = 2447 mi^2)							
w/o project	130,000	45,000	23,000	17,000	12,000	7,100	1,800
w/project	44,000	40,000	27,000	21,000	13,000	7,100	1,800

Note: D.A. = drainage area.

Table 7-10. Santa Ana River Mainstem Discharge-Frequency Values.
(Future Conditions)

Location	Frequency of Peak Discharge (in ft^3/s)						
	200-YR	100-YR	50-YR	25-YR	10-YR	5-YR	2-YR
at Seven Oaks Dam (D.A. = 177 mi^2)							
Inflow							
w/o project and w/project	88,000	58,000	34,000	20,500	8,800	4,300	1,100
Outflow							
w/o project			same as inflow				
w/project	6,900	5,500	4,200	3,150	2,150	2,000	500
D/S of Mill Creek (D.A. = 242 mi^2)							
w/o project	120,000	76,000	45,000	26,000	11,700	5,600	1,400
w/project	37,000	25,000	15,500	9,300	4,300	2,050	760
D/S of City Creek (D.A. = 290 mi^2)							
w/o project	125,000	80,000	48,000	28,000	12,500	5,800	1,400
w/project	50,000	33,000	21,000	13,000	5,600	2,600	800
at E Street (D.A. = 500 mi^2)							
w/o project	170,000	111,000	64,000	36,000	14,500	6,300	1,450
w/project	110,000	70,000	42,000	24,000	9,400	4,000	920
at Riverside Narrows (D.A. = 824 mi^2)							
w/o project	280,000	190,000	115,000	62,000	26,000	11,000	2,200
w/project	220,000	140,000	82,000	47,000	19,000	8,100	1,680
at Prado Dam (D.A. = 2255 mi^2)							
Inflow							
w/o project	380,000	270,000	155,000	85,000	34,000	14,000	3,400
w/project	320,000	230,000	135,000	75,000	30,000	13,000	3,100
Outflow							
w/o project	240,000	115,000	21,000	6,900	6,400	4,700	2,400
w/project	30,000	30,000	30,000	22,000	11,000	6,000	3,[illegible]00
at Imperial Hwy (D.A. = 2306 mi^2)							
w/o project	240,000	110,000	22,000	7,000	6,500	4,800	2,500
w/project	40,000	36,000	34,000	25,000	13,000	7,200	3,800
at Santa Ana (D.A. = 2447 mi^2)							
w/o project	220,000	90,000	30,000	20,400	13,000	8,400	4,700
w/project	50,000	42,000	37,000	27,500	18,000	11,000	4,700

Note: D.A. = drainage area.

Table 7-11. Santa Ana River Mainstem Standard Project Flood. (Peak Discharges)

Drainage Location	Area (mi^2)	Present (ft^3/s)	Future (ft^3/s)
at Seven Oaks Dam	177		
Inflow			
w/o project and w/project		82,000	82,000
Outflow			
w/o project		82,000	82,000
w/project		6,700	6,900
D/S of Mill Creek	242		
w/o project		112,000	112,000
w/project		37,000	37,000
D/S of City Creek	290		
w/o project		115,000	115,000
w/project		46,000	47,000
at E Street	500		
w/o project		164,000	164,000
w/project		100,000	100,000
at Riverside Narrows	824		
w/o project		228,000	240,000
w/project		200,000	187,000
at Prado Dam	2,255		
Inflow			
w/o project		282,000	317,000
w/project		230,000	275,500
Outflow			
w/o project		150,000	239,000
w/project		30,000	30,000
at Imperial Hwy	2,306		
w/o project		147,000	235,000
w/project		36,000	38,000
at Santa Ana	2,447		
w/o project		122,000	214,000
w/project		43,000	47,000

Table 7-12. Seven Oaks Dam Operation Schedule.
(Present Conditions)

Level	Elev. (ft) NGVD	Gross Storage (ac-ft)	Outflow (ft^3/s) Min.	Rising*	Falling*	Max.
	2100	0	0	0	0	0
	2110	18	10	0	**	10
	2150	552	10	0	**	500
Top of Debris Pool:	2200	2,968	10	500	500	500
	2264	10,120	10	500	500	500
	2265	10,270	10	50	500	500
	2269	10,882	10	50	1,000	1,000
	2273	11,512	10	50	1,500	1,500
	2278	12,324	10	50	2,000	2,000
	2298	15,906	10	50	2,000	2,000
	2299	16,099	10	500	2,000	2,000
	2300	16,293	100	500	2,030	5,000
	2400	43,327	200	500	4,340	6,500
	2500	90,398	200	500	6,560	7,000
	2570	137,830	200	500	6,950	7,800
Spillway Crest:	2580	145,608	200	500	7,000	8,000
	2585	149,604	0	0	0	16,000
	2590	153,673	0	0	0	43,000
	2600	162,032	0	0	0	126,000
Top of Dam:	2610	170,685	0	0	0	243,000

* The "Rising Pool at Prado Dam" operation (i.e., maximum release rate equals 500 ft^3/s) is used until the flood event at Prado Dam has passed. The "Falling Pool at Prado Dam" operation (i.e., maximum release rate equals 7,000 ft^3/s) is then implemented.

** The release rate is equal to 10 to 20 ft^3/s in addition to inflow up to elev. 2200 feet NGVD in order to drain the debris pool. When debris pool is required to be maintained, outflow equals inflow.

Table 7-13. Seven Oaks Dam Operation Schedule.
(Future Conditions)

Level	Elev. (ft) NGVD	Net Storage (ac-ft)	Outflow (ft^3/s)			
			Min.	Rising*	Falling*	Max.
	2265	0	0	0	0	0
	2269	10	10	50	**	1,000
	2273	38	10	50	**	1,500
	2278	102	10	50	**	2,000
	2298	758	10	50	**	2,000
	2299	808	10	50	**	2,000
Top of Debris Pool:	2300	859	100	500	500	2,000
	2325	2,773	100	500	2,000	4,900
	2350	5,917	100	500	2,075	5,500
	2400	16,450	200	500	2,840	6,000
	2450	33,985	200	500	4,000	6,400
	2500	58,858	200	500	5,700	6,750
	2525	74,061	200	500	6,440	6,950
	2550	91,054	200	500	6,680	7,300
	2575	109,685	200	500	6,925	7,700
Spillway	2580	113,608	200	500	7,000	8,000
Crest:	2585	117,604	0	0	0	16,000
	2590	121,673	0	0	0	43,000
	2600	130,032	0	0	0	126,000
Top of Dam:	2610	138,685	0	0	0	243,000

* The "Rising Pool at Prado Dam" operation (i.e., maximum release rate equals 500 ft^3/s) is used until the flood event at Prado Dam has passed. The "Falling Pool at Prado Dam" operation (i.e., maximum release rate equals 7,000 ft^3/s) is then implemented.

** The release rate is equal to 10 to 20 ft^3/s in addition to inflow up to elev. 2300 feet NGVD in order to drain the debris pool. When debris pool is required to be maintained, outflow equals inflow.

Table 7-14. Prado Dam Operation Schedule, With Project. (Present Conditions)

Elevation (ft, NGVD)	Gross Storage (ac-ft)	Minimum Outflow (ft^3/s)	Nominal Outflow (ft^3/s)	Maximum Outflow (ft^3/s)	Spillway Flow* (ft^3/s)
470 (Gate Sill)	0	0	0	0	0
490 (Debris Pool)	4,474	50	200	1,500	0
500	18,426	50	1,000	2,000	0
501	20,369	50	2,000	4,000	0
510	42,369	100	4,000	8,000	0
520	76,646	100	12,000	15,000	0
530	120,988	200	20,000	20,000	0
540	176,965	200	30,000	30,000	0
550	246,315	300	30,000	30,000	0
560	332,220	300	30,000	30,000	0
563 (Spillway Crest)	362,026	300	30,000	30,000	0
564	372,281	0	26,843	26,843	3,157
565	383,044	0	20,870	20,870	9,130
566	393,806	0	12,872	12,872	17,128
568	416,263	0	0	0	38,300
570	439,622	0	0	0	65,650
580	570,607	0	0	0	279,700
585	645,800	0	0	0	425,160
590	729,600	0	0	0	587,600
594.4 (Top of Dam)	795,000	0	0	0	720,000

*Spillway Length = 1000 ft.

Table 7-15. Prado Dam Operation Schedule, With Project. (Future Conditions)

Elevation (ft, NGVD)	Net Storage (ac-ft)	Minimum Outflow (ft^3/s)	Nominal Outflow (ft^3/s)	Maximum Outflow (ft^3/s)	Spillway* Flow (ft^3/s)
470 (Gate Sill)	0	0	0	0	0
490 (Debris Pool)	23	50	300	1,500	0
500	4,000	50	1,500	2,000	0
501	6,000	50	3,000	4,000	0
510	18,100	100	4,000	8,000	0
520	42,200	100	12,000	15,000	0
530	76,500	200	20,000	20,000	0
540	123,000	200	30,000	30,000	0
550	183,900	300	30,000	30,000	0
560	263,500	300	30,000	30,000	0
563 (Spillway Crest)	292,026	300	30,000	30,000	0
564	302,281	0	26,843	26,843	3,157
565	313,044	0	20,870	20,870	9,130
566	323,806	0	12,872	12,872	17,128
568	346,263	0	0	0	38,300
570	369,622	0	0	0	65,650
580	500,607	0	0	0	279,700
585	575,800	0	0	0	425,160
590	659,600	0	0	0	587,600
594.4 (Top of Dam)	725,000	0	0	0	720,000

* Spillway Length = 1000 ft.

Table 7-16. Analytical Frequency Analysis of Peak Flows
City Creek Near Highland, California
USGS Gauge 11055800 - Drainage Area = 19.6 mi^2

Analyzed Data Water Year	Analyzed Data Peak Discharge (ft^3/s)	Rank	Ordered Data Water Year	Ordered Data Peak Discharge (ft^3/s)	Median Plotting Position
1920	350	1	1969	7000	0.0105
1921	1320	2	1938	6000	0.0256
1922	1090	3	1980	3630	0.0407
1923	720	4	1967	3080	0.0557
1924	345	5	1978	2510	0.0708
1925	74	6	1941	2420	0.0858
1926	2360	7	1926	2360	0.1009
1927	1930	8	1943	2300	0.1160
1928	369	9	1927	1930	0.1310
1929	196	10	1957	1600	0.1461
1930	78	11	1937	1500	0.1611
1931	146	12	1958	1350	0.1762
1932	442	13	1921	1320	0.1913
1933	62	14	1966	1310	0.2063
1934	374	15	1983	1140	0.2214
1935	166	16	1922	1090	0.2364
1936	580	17	1944	1030	0.2515
1937	1500	18	1946	1000	0.2666
1938	6900	19	1945	940	0.2916
1939	400	20	1952	937	0.2967
1940	378	21	1956	862	0.3117
1941	2420	22	1977	860	0.3268
1942	172	23	1972	722	0.3419
1943	2300	24	1923	720	0.3569
1944	1030	25	1962	648	0.3720
1945	940	26	1954	631	0.3870
1946	1000	27	1936	580	0.4021
1947	285	28	1973	492	0.4172
1948	250	29	1932	442	0.4322
1949	100	30	1939	400	0.4473
1950	198	31	1940	378	0.4623
1951	71	32	1934	374	0.4774
1952	937	33	1928	369	0.4925
1953	132	34	1979	359	0.5075
1954	631	35	1959	358	0.5226
1955	115	36	1920	350	0.5377
1956	862	37	1924	345	0.5527
1957	1600	38	1982	330	0.5678
1958	1350	39	1976	326	0.5828
1959	358	40	1984	287	0.5979
1960	42	41	1947	285	0.6130
1961	92	42	1948	250	0.6280
1962	648	43	1965	226	0.6431
1963	163	44	1968	217	0.6581
1964	64	45	1970	205	0.6732

Table 7-16. (Continued)

Analyzed Data Water Year	Analyzed Data Peak Discharge (ft^3/s)	Rank	Water Year	Ordered Data Peak Discharge (ft^3/s)	Median Plotting Position
1965	226	46	1985	200	0.6883
1966	1310	47	1950	198	0.7033
1967	3080	48	1929	196	0.7184
1968	217	49	1942	172	0.7334
1969	7000	50	1935	166	0.7485
1970	205	51	1963	163	0.7636
1971	100	52	1931	146	0.7786
1972	722	53	1953	132	0.7937
1973	492	54	1974	126	0.8087
1974	126	55	1955	115	0.8238
1975	103	56	1975	103	0.8389
1976	326	57	1981	103	0.8539
1977	860	58	1971	100	0.8690
1978	2510	59	1949	100	0.8840
1979	359	60	1961	92	0.8991
1980	3630	61	1930	78	0.9142
1981	103	62	1925	74	0.9292
1982	330	63	1951	71	0.9443
1983	1140	64	1964	64	0.9593
1984	287	65	1933	62	0.9744
1985	200	66	1960	42	0.9895

Final Peak Discharge vs. Frequency Estimates:

Exceedance Probability	Computed Discharge (ft^3/s)	Expected Probability Discharge (ft^3/s)	Confidence Limit (ft^3/s)	Confidence Limit (ft^3/s)
.002	21800	26700	44600	12600
.005	13600	15900	26000	8310
.010	9350	10500	16800	5930
.020	6240	6800	10600	4130
.040	3460	3650	5390	2430
.100	2090	2160	3050	1530
.200	1160	1180	1580	884
.500	399	399	511	310
.800	149	147	196	109
.900	92	90	125	64
.950	63	61	88	42
.990	32	30	48	19

Final Statistics based on 66 years of record:

Mean Logarithm	2.6260
Standard Deviation	0.5305
Computed Skew	0.2748
Generalized Skew	0.3250
Adopted Skew	0.2869

Table 7-17. Analytical Frequency Analysis of Peak Flows
Plunge Creek Near East Highland, California
USGS Gauge 11055500 - Drainage Area = 16.9 mi^2

Analyzed Data Water Year	Analyzed Data Peak Discharge (ft^3/s)	Rank	Ordered Data Water Year	Ordered Data Peak Discharge (ft^3/s)	Median Plotting Position
1919	39	1	1938	5340	0.0104
1920	440	2	1978	5340	0.0252
1921	1100	3	1967	4770	0.0401
1922	924	4	1969	4610	0.0549
1923	390	5	1966	4200	0.0697
1924	218	6	1971	3000	0.0846
1925	20	7	1980	1780	0.0994
1926	840	8	1958	1720	0.1142
1927	1420	9	1943	1700	0.1291
1928	240	10	1956	1630	0.1439
1929	176	11	1957	1630	0.1588
1930	143	12	1946	1500	0.1736
1931	170	13	1927	1420	0.1884
1932	359	14	1983	1360	0.2033
1933	80	15	1945	1280	0.2181
1934	380	16	1921	1100	0.2329
1935	210	17	1922	924	0.2478
1936	330	18	1926	840	0.2626
1937	725	19	1972	785	0.2774
1938	5340	20	1937	725	0.2923
1939	480	21	1941	710	0.3071
1940	660	22	1954	683	0.3220
1941	710	23	1940	660	0.3368
1942	132	24	1959	602	0.3516
1943	1700	25	1962	536	0.3665
1944	380	26	1939	480	0.3813
1945	1280	27	1973	466	0.3961
1946	1500	28	1982	465	0.4110
1947	170	29	1977	450	0.4258
1948	195	30	1920	440	0.4407
1949	69	31	1974	414	0.4555
1950	156	32	1976	395	0.4703
1951	52	33	1923	390	0.4852
1952	360	34	1944	380	0.5000
1953	62	35	1934	380	0.5148
1954	683	36	1965	371	0.5297
1955	49	37	1952	360	0.5445
1956	1630	38	1932	359	0.5593
1957	1630	39	1981	351	0.5742
1958	1720	40	1979	350	0.5890
1959	602	41	1936	330	0.6039
1960	29	42	1984	250	0.6187
1961	26	43	1975	248	0.6335
1962	536	44	1928	240	0.6484
1963	99	45	1924	218	0.6632

Table 7-17. (Continued)

Analyzed Data Water Year	Analyzed Data Peak Discharge (ft^3/s)	Rank	Water Year	Ordered Data Peak Discharge (ft^3/s)	Median Plotting Position
1964	48	46	1935	210	0.6780
1965	371	47	1948	195	0.6929
1966	4200	48	1968	190	0.7077
1967	4770	49	1929	176	0.7226
1968	190	50	1947	170	0.7374
1969	4610	51	1931	170	0.7522
1970	100	52	1950	156	0.7671
1971	3000	53	1930	143	0.7819
1972	785	54	1942	132	0.7967
1973	466	55	1985	122	0.8116
1974	414	56	1970	100	0.8264
1975	248	57	1963	99	0.8412
1976	395	58	1933	80	0.8561
1977	450	59	1949	69	0.8709
1978	5340	60	1953	62	0.8858
1979	350	61	1951	52	0.9006
1980	1780	62	1955	49	0.9154
1981	351	63	1964	48	0.9303
1982	465	64	1919	39	0.9451
1983	1360	65	1960	29	0.9599
1984	250	66	1961	26	0.9748
1985	122	67	1925	20	0.9896

Final Peak Discharge vs. Frequency Estimates:

Exceedance Probability	Computed Discharge (ft^3/s)	Expected Probability Discharge (ft^3/s)	Confidence Limit (ft^3/s)	Confidence Limit (ft^3/s)
.002	19700	23500	40500	11300
.005	12900	14800	24900	7760
.010	9130	10100	16700	5690
.020	6260	6770	10900	4050
.040	3560	3740	5710	2430
.100	2160	2230	3250	1540
.200	1180	1200	1670	879
.500	378	378	497	287
.800	122	120	164	87
.900	68	66	95	45
.950	42	40	61	26
.990	17	15	27	9

Final Statistics based on 67 years of record:

Mean Logarithm	2.5810
Standard Deviation	0.5859
Computed Skew	-0.0377
Generalized Skew	0.3250
Adopted Skew	0.0384

Table 7-18. Analytical Frequency Analysis of Peak Flows
Mill Creek Near Yucaipa, California
USGS Gauge 11054000 - Drainage Area = 43.0 mi^2

Analyzed Data Water Year	Analyzed Data Peak Discharge (ft^3/s)	Rank	Water Year	Ordered Data Peak Discharge (ft^3/s)	Median Plotting Position
1920	650	1	1938	18100	0.0104
1921	280	2	1969	18000*	0.0252
1922	896	3	1966	10000	0.0401
1923	440	4	1967	10000	0.0549
1924	-1	5	1980	5550	0.0697
1925	3	6	1978	5400	0.0846
1926	900	7	1976	5000	0.0994
1927	4500	8	1927	4500	0.1142
1928	105	9	1937	2390	0.1291
1929	-1	10	1971	1200	0.1439
1930	55	11	1961	1060	0.1588
1931	-1	12	1958	990	0.1736
1932	400	13	1926	900	0.1884
1933	12	14	1922	896	0.2033
1934	328	15	1952	738	0.2181
1935	246	16	1920	650	0.2329
1936	620	17	1936	620	0.2478
1937	2390	18	1983	587	0.2626
1938	18100	19	1984	564	0.2774
1939	-1	20	1923	440	0.2923
1940	-1	21	1986	425	0.3071
1941	-1	22	1959	415	0.3220
1942	-1	23	1954	410	0.3368
1943	-1	24	1932	400	0.3516
1944	-1	25	1934	328	0.3665
1945	-1	26	1968	324	0.3813
1946	-1	27	1979	290	0.3961
1947	-1	28	1921	280	0.4110
1948	5	29	1972	266	0.4258
1949	-1	30	1957	256	0.4407
1950	170	31	1935	246	0.4555
1951	46	32	1982	238	0.4703
1952	738	33	1965	235	0.4852
1953	178	34	1962	208	0.5000
1954	410	35	1956	193	0.5148
1955	139	36	1953	178	0.5297
1956	193	37	1950	170	0.5445
1957	256	38	1960	167	0.5593
1958	990	39	1963	150	0.5742
1959	415	40	1974	140	0.5890
1960	167	41	1955	139	0.6039
1961	1060	42	1970	136	0.6187
1962	208	43	1964	135	0.6335
1963	150	44	1981	134	0.6484
1964	135	45	1975	120	0.6632
1965	235	46	1977	111	0.6780

Table 7-18. (Continued)

Analyzed Data Water Year	Analyzed Data Peak Discharge (ft^3/s)	Rank	Water Year	Ordered Data Peak Discharge (ft^3/s)	Median Plotting Position
1966	10000	47	1928	105	0.6929
1967	10000	48	1973	92	0.7077
1968	324	49	1930	55	0.7226
1969	35400	50	1951	46	0.7374
1970	136	51	1933	12	0.7522
1971	1200	52	1948	5	0.7671
1972	265	53	1925	3	0.7816
1973	92	54	1939	-1	0.7967
1974	140	55	1941	-1	0.8116
1975	120	56	1949	-1	0.8264
1976	5000	57	1943	-1	0.8412
1977	111	58	1944	-1	0.8561
1978	5400	59	1929	-1	0.8709
1979	290	60	1946	-1	0.8858
1980	5550	61	1924	-1	0.9006
1981	134	62	1931	-1	0.9154
1982	238	63	1942	-1	0.9303
1983	5870	64	1945	-1	0.9451
1984	564	65	1947	-1	0.9599
1985	-1	66	1985	-1	0.9748
1986	425	67	1940	-1	0.9896

Final Peak Discharge vs. Frequency Estimates:

Exceedance Probability	Computed Discharge (ft^3/s)	Expected Probability Discharge (ft^3/s)	Confidence Limit (ft^3/s)	Confidence Limit (ft^3/s)
.002	71400	91300	213000	30700
.005	39600	47800	108000	18100
.010	24200	28100	61400	11700
.020	14100	15800	33000	7180
.040	6180	6640	13000	3410
.100	2950	3080	5620	1730
.200	1190	1210	2050	740
.500	200	200	310	130
.800	32	31	51	19
.900	12	11	21	6
.950	5	5	10	3
.990	1	1	2	0

Final Statistics based on 67 years of record:

Mean Logarithm	2.2859
Standard Deviation	0.9314
Computed Skew	-0.2004
Generalized Skew	0.325
Adopted Skew	-0.1000

-1: Missing Record

*18,000 ft^3/s is Corps of Engineners estimate, U.S.G.S. estimate of 35,400 ft^3/s is a poor value due to excessive bulking of flows at gauge location.

Table 7-19. 100-Year Design Flood Peak Discharges Along Oak Street Drain, Future Conditions, With Recommended Plan.

Concentration Point	Subarea	Drainage Area Contributed (mi^2)	Peak Discharges (ft^3/s)
Oak Street Debris Basin	B	6.13	4,300
Oak Street Drain before Confluence with Proposed Lincoln Ave. Diversion	B, E1	6.76	4,600
Mountain Subarea	C	1.24	1,400
End of Proposed Lincoln Ave.	C, D	2.51	2,400
Confluence of Oak Street Drain and Lincoln Ave Diversion	B, C, D, E1	9.27	6,100
Mabey Canyon Debris	A	1.50	1,200
End of Mangular Border Drain	A, E2	2.12	1,700
Confluence of Oak Street Drain and Mangular Border Drain	A, B, C, D, E1, E2	11.39	7,100
Riverside Freeway	A, B, C, D, E1, E2, E3, E4	11.80	7,100
Oak Street Drain before Confluence with Main Street Drain	A, B, C, D, E1, E2, E3, E4, F	11.95	7,100
Main Street Drain	G	2.97	2,900
Confluence of Main Street Drain & Oak Street Drain	A, B, C, D, E1, E2, E3, E4, F, G	14.92	8,000

(1) See plate 7-57 for location.

Table 7-20. Annual Maximum Runoff Values, Santiago Creek, Orange County, California.

Water Year	ANALYZED DATA Peak (ft^3/s)	1-Day (ft^3/s)	2-Day (ft^3/s)	3-Day (ft^3/s)	Plotting Position	ORDERED DATA Peak (ft^3/s)	1-Day (ft^3/s)	2-Day (ft^3/s)	3-Day (ft^3/s)
1933	144	40	28	19	1.17**	10,740**	8,000**	7,450**	5,633**
1934	271	103	54	38	3.60	5,200	3,190	2,925	2,347
1935	194	30	28	23	5.70	3,330	1,796	1,621	1,454
1936	142	20	13	10	7.80	3,300	1,220	1,135	990
1937	1,360	595	460	396	9.90	3,000	1,000	989	924
1938	5,200	3,190	2,925	2,347	12.00	2,420	595	460	396
1939	76	8	5	4	14.10	1,800	593	363	310
1940	50	3	2	2	16.20	1,360	593	336	258
1941	1,800	1,220	1,135	990	18.30	970	219	173	163
1942	2	1	1	1	20.50	955	216	150	123
1943	2,420	1,000	989	924	22.60	900	179	135	122
1944	3,000	593	363	258	24.70	868	175	108	101
1945	330	149	135	123	26.80	825	174	108	81
1946	150	47	37	25	28.90	804	149	103	72
1947	40	10	7	5	31.00	625	116	60	51
1948	1	1	1	1	33.10	500	103	58	41
1949	407	36	25	16	35.20	494	98	58	40
1950	804	116	60	40	37.30	440	95	54	38
1951	139	9	4	3	39.40	407	73	50	34
1952	3,300	593	336	310	41.60	388	67	40	27
1953	955	30	21	14	43.70	330	47	37	25
1954	494	95	50	34	45.80	271	40	28	23
1955	104	11	6	4	47.90	206	38	28	19

*Estimated
**1969 flow is largest flood occurring within period from 1921-1979, therefore 1969 is plotted at n = 59

Table 7-20. Continued

	ANALYZED DATA					ORDERED DATA				
Water Year	Peak (ft^3/s)	1-Day (ft^3/s)	2-Day (ft^3/s)	3-Day (ft^3/s)	Plotting Position	Peak (ft^3/s)	1-Day (ft^3/s)	2-Day (ft^3/s)	3-Day (ft^3/s)
1956	868	219	150	101	50.00	194	36	26	19
1957	144	19	10	7	51.50	170	30	25	16
1958	825	175	103	122	53.60	150	30	22	14
1959	128	12	6	4	55.70	144	29	21	14
1960	26	1	1	1	57.80	144	27	19	14
1961	388	15	8	5	59.90	142	23	14	13
1962	98	8	6	4	62.00	139	20	13	10
1963	5	1	1	1	64.10	128	19	10	8
1964	50	9	6	4	66.20	108	15	8	7
1965	55	9	6	4	68.30	106	14	8	6
1966	440	73*	40*	27*	70.50	104	12	8	5
1967	970	98	58	51	72.60	98	11	7	5
1968	900	216	108	72	74.00	76	10	6	4
1969	10,740	8,000	7,450	5,633	76.00	55	9	6	4
1970	28	27	22	14	78.90	50	9	6	4
1971	170	29	26	19	81.00	50	8	5	4
1972	108	38	19	13	83.10	40	8	4	3
1973	625	179	108	81	85.20	28	3	2	2
1974	206	67	58	41	87.30	26	1	1	1
1975	106	23	14	14	89.40	24	1	1	1
1976	14	9	8	8	91.60	14	1	1	1
1977	24	14	8	6	93.70	5	1	1	1
1978	3,330	1,796	1,621	1,454	95.80	2	0	0	0
1979	500	174	173	163	97.90	1	0	0	0

*Estimated

**1969 flow is largest flood occurring within period from 1921-1979, therefore 1969 is plotted at n = 59

Table 7-21. Analytical Frequency Analysis of Peak Flows.

Handy Creek, Orange, California
OCEMA* NO. 152
Drainage Area = 3.2 mi^2

Analyzed Data			Ordered Data		
Water Year	Peak Discharge (ft^3/s)	Rank	Water Year	Peak Discharge (ft^3/s)	Median Plotting Position
1938	901.	1	1983	1490.	.0154
1939	1000.	2	1944	1220.	.0374
1940	322.	3	1952	1190.	.0595
1941	562.	4	1978	1050.	.0815
1942	91.	5	1939	1000.	.1035
1943	537.	6	1980	960.	.1256
1944	1220.	7	1938	901.	.1476
1945	267.	8	1979	890.	.1696
1946	251.	9	1969	870.	.1916
1947	256.	10	1941	562.	.2137
1948	30.	11	1943	537.	.2357
1949	27.	12	1971	470.	.2577
1950	78.	13	1981	470.	.2797
1951	49.	14	1982	390.	.3018
1952	1190.	15	1985	370.	.3238
1953	236.	16	1956	346.	.3458
1954	80.	17	1940	322.	.3678
1955	39.	18	1958	303.	.3899
1956	346.	19	1967	290.	.4119
1957	84.	20	1966	285.	.4339
1958	303.	21	1945	267.	.4559
1959	180.	22	1947	256.	.4780
1960	47.	23	1946	251.	.5000
1961	6.	24	1953	236.	.5220
1962	65.	25	1976	202.	.5441
1966	285.	26	1984	202.	.5661
1967	290.	27	1973	192.	.5881
1968	67.	28	1970	178.	.6101
1969	870.	29	1974	178.	.6322
1970	178.	30	1975	173.	.6542
1971	470.	31	1977	164.	.6762
1972	132.	32	1972	132.	.6982
1973	192.	33	1959	108.	.7203
1974	178.	34	1942	91.	.7423
1975	173.	35	1957	85.	.7643
1976	202.	6	1954	80.	.7863
1977	164.	37	1950	78.	.8084
1978	1050.	38	1968	67.	.8304

*OCEMA = Orange County Environmental Management Agency

Table 7-21. (Continued)

Analyzed Data		Ordered Data			
Water Year	Peak Discharge (ft^3/s)	Rank	Water Year	Peak Discharge (ft^3/s)	Median Plotting Position
1979	890.	39	1962	65.	.8524
1980	960.	40	1951	49.	.8744
1981	470.	41	1960	47.	.8965
1982	390.	42	1955	39.	.9185
1983	1490.	43	1948	30.	.9405
1984	202.	44	1949	27.	.9626
1985	370.	45	1961	6.	.9846

Final Peak Discharge vs. Frequency Estimates:

Exceedance Probability	Computed Discharge (ft^3/s)	Expected Probability Discharge (ft^3/s)	0.05 Confidence Limit (ft^3/s)	0.95 Confidence Limit (ft^3/s)
.002	4140.	4940.	8180.	2520.
.005	3130.	3590.	5860.	1980.
.010	2480.	2760.	4430.	1610.
.020	1910.	2070.	3260.	1280.
.040	1420.	1510.	2310.	986.
.100	895.	925.	1340.	649.
.200	572.	583.	807.	430.
.500	236.	236.	309.	181.
.800	94.	92.	125.	67.
.900	57.	55.	79.	38.
.950	37.	35.	54.	23.
.990	17.	15.	26.	9.

Final Statistics based on 45 years of record:

Mean Logarithm	2.3614
Standard Deviation	.4671
Computed Skew	-0.1551
Generalized Skew	-0.2000
Adopted Skew	-0.1565

Table 22. 100-Year Design Peak Discharges Along the Santiago Creek, Future Conditions, With Recommended Plan.

Location	Flow Rate (cfs)
Outflow from Villa Park Dam	5,700
Villa Park Road	5,700
Outflow from Santiago Creek Reservoir	3,500
Prospect Avenue	3,500
Walnut Avenue	3,700
Chapman Avenue	3,900
Tustin Avenue	4,200
Garden Grove Freeway	4,500
Santa Ana Freeway	4,700
Confluence with Santa Ana River	5,000

Table 7-23. Starting Elevation of Flood Control Storage Villa Park and Santiago Creek Reservoirs.

December through February			During March	
Santiago Dam At or Below Water Surface Elevation (ft, NGVD)	Villa Park Dam At or Below Water Surface Elevation (ft, NGVD)	Santiago Creek Reservoir At or Below Water Surface Elevation (ft, NGVD)	Villa Park Dam At or Below Water Surface Elevation (ft, NGVD)	Santiago Creek Reservoir At or Below Water Surface Elevation (ft, NGVD)
790	510	274	510	280
789	510	278	510	280
788	510	280	510	280
787	510	280	510	281
786	510	280	510	282
784	510	280	510	284
782	510	280	510	286
780	510	280	510	288
778	510	280	521	290
776	510	280	532	293

During the period of April through November, the starting elevation of the flood control storage of the reservoir will be elevation 293 feet NGVD regardless of the storage space available in Santiago Dam and Villa Park Dam.

See paragraphs 5-37, 5-38, 8-11 and 8-12 to determine the outflow from Santiago Creek Reservoir. Gate operations for Villa Park Dam will be as specified in the OCEMA Villa Park Dam Operation Manual.

Table 7-24. Santiago Creek Reservoir (Blue Diamond-Bond Pits). Release Schedule

Elevation NGVD (ft)	Total Storage (ac-ft)	Storage Above Elev. 274 (ac-ft)	Gated Outflow (ft^3/s)
268.00	9,344	0	0
270.00	9,632	0	260
271.00	9,805	0	480
272.00	9,977	0	730
273.00	10,150	0	1,000
274.00	10,322	0	1,290
275.00	10,495	173	1,600
276.00	10,677	345	1,940
277.00	10,840	518	2,300
278.00	11,012	690	2,680
279.00	11,185	863	3,080
280.00	11,357	1,035	3,500
285.00	12,352	2,030	3,500
290.00	13,348	3,026	3,500
293.00	13,945	3,623	3,500
295.00	14,343	4,021	3,500
298.00 (Overflow Structure Crest)	14,940	4,618	3,500
300.00	15,297	4,975	7,000*

* For pool elevations above 298 feet NGVD, the service gates will be set such that at pool elevation of 300 feet NGVD, the sum of the overflow and gated outflow is approximately 7,000 ft^3/s.

Table 7-25. Oak Street Drain Debris Basin, Debris Production Factors and Results.

Drainage Area (mi^2)	Slope (ft/mi)	Drainage Density	Hypsometric Index	3-Hour Rainfall (in)
6.1	590	1.81	0.40	2.8

Correction Factors

Slope	Drainage Density	Hypsometric Index	3-Hour Rainfall	Total %
64%	96%	89%	60%	33%

Resulting Data

Recommended Production for Drainage Area (cubic yards)	Resulting Volume for Drainage Area (acre-feet)
1,100,000	224

Table 7-26. Santa Ana River Basin Major Water Storage Facilities.

Name	Drainage Area (mi^2)	Storage (ac-ft)	Controllable Flood Releases	Owner/ Operator	Water-course	Outlet Capacity (ft^3/s)	Maximum Scheduled Outflow (ft^3/s)	Year Completed
Prado Dam	2255.0	196,235	Yes	Corps of Engineers	Santa Ana River	17,000	5,000	1940
San Antonio Dam	27.0	7,703	Yes	Corps of Engineers	San Antonio Creek	11,800	8,000	1956
Carbon Cyn. Dam	19.3	6,614	Yes	Corps of Engineers	Carbon Cyn. Creek	1,480	1,100	1961
Villa Park Dam	83.3	16,044	Yes	O.C.E.M.A.(1)	Santiago Ck.	6,000	3,500(5)	1963
Seven Oaks Dam*	177.0	145,600	Yes	Corps of Engineers	Santa Ana River	8,000	7,000	---
Big Bear Lake	38.0	63,381	No	Bear Valley Municipal Water Dist.	Bear Creek	---	---	1911
Railroad Canyon Reservoir	641.0	11,459	No	Temescal Water Co.	San Jacinto River	1,450	As req. for irrigation	1928
Lake Elsinore	52.0	122,500	No	R.C.F.C.- W.C.D.(2)	San Jacinto Riv. Temescal Wash	700	None	N/A
Santiago Reservoir	63.2	25,000	No	Serrano Irr. District	Santiago Creek	---	As req. for irrigation	1931

NOTE: See footnotes at end of table.

Table 7-26. (Continued)

Name	Drainage Area (mi^2)	Storage (ac-ft)	Controllable Flood Releases	Owner/ Operator	Water-course	Outlet Capacity (ft^3/s)	Maximum Scheduled Outflow (ft^3/s)	Year Completed
Santiago Creek Reservoir* (Gravel Pits)	94.6	13,299	No	O.C.W.D.(3)	Santiago Creek	3,500	3,500	*
Lake Mathews	40.0	182,804	No	M.W.D.(4)	Temescal Wash	---	---	1938
Lake Hemet	67.0	14,000	No	Lake Hemet Municipal Water Dist.	San Jacinto River	---	---	1895

(1) Orange County Environmental Management Agency
(2) Riverside County Flood Control and Water Conservation District
(3) Orange County Water District
(4) Metropolitan Water District
(5) 3,500 ft^3/s maximum design outflow with 6,000 ft^3/s on approval of Chief Engineer

* Not yet built.
N/A Not available.

Table 7-27. Hydrometeorological Instrumentation.

Gauge Location or Description	Existing Sensor Elev.	Existing Sensor Flow	Existing Sensor Precip.	Existing Sensor RTU	New Sensors Elev.	New Sensors Flow	New Sensors Precip.	New Sensors RTU
For Seven Oaks Dam								
Seven Oaks Dam					X		X	X
SAR near Mentone (USGS 11051500)		X				X	X	X
NWS Station at Big Bear Lake Dam							X	X
NWS Station at Camp Angelus							X	X
NWS Station at Seven Oaks							X	X
For Prado Dam								
Prado Dam	X		X	X	X		X	X
SAR below Prado Dam (USGS 11074000)		X	X	X		X	X	X
Mill Creek (USGS 11054000)		X				X	X	X
Plunge Creek (USGS 11055000)		X				X	X	X
Santa Ana River		X				X	X	X
at MWD Crossing (USGS 11066460)								
City Creek (USGS 11055800)		X				X	X	X
NWS Station at Lytle Creek Fire Station							X	X

Table 7-27. (Continued)

Gauge Location or Description	Existing Sensor				New Sensors			
	Elev.	Flow	Precip.	RTU	Elev.	Flow	Precip.	RTU
				For Prado Dam (Continued)				
NWS Station at Winchester							X	X
NWS Station at March AF Base							X	X
				For Santiago Reservoir				
Santiago Dam	X		X		X		X	X
Santiago Creek Reservoir					X		X	X
Santiago Creek below Santiago Creek Reservoir						X	X	X
Santiago Creek at Santa Ana (USGS 11077500)						X	X	X

Table 7-28. Existing Prado Dam Release Schedule.

Elevation (ft, NGVD)	Net Storage (ac-ft)	Net Area (ac)	Outlet Outflow (ft^3/s)	Outflow At Spillway (ft^3/s)	Total Outflow (ft^3/s)
460 (Gate Sill)	0	0	0	0	0
461	0	0	200-300	0	300
490 (Debris Pool)	4,474	919	200-300	0	300
494	9,100	1,295	5,000	0	5,000
495	10,257	1,389	5,000	0	5,000
500	18,426	1,888	5,000	0	5,000
504	26,832	2,300	5,000	0	5,000
510	42,389	2,868	5,000	0	5,000
514	54,797	3,313	5,000	0	5,000
520	76,646	3,939	5,000	0	5,000
530	120,988	4,940	5,000	0	5,000
540	176,965	6,228	5,000	0	5,000
543 (Spillway Crest)	196,000	6,330	5,000	0	5,000
550	246,315	7,693	0	66,000	66,000
560	332,220	9,556	0	275,000	275,000
566 (Top of Dam)	393,806	11,007	0	432,000	432,000

Table 7-29. Beneficial Uses for Seven Oaks Dam.

Water Body	MUN	AGR	IND	PROC	GWR	POW	REC-1	REC-2	WARM	COLD	WILD
Santa Ana River Reach 5, confluence with Bear Creek to San Jacinto Fault	X	X			I	X	I	X	I	I	

MUN	- Municipal and Domestic Supply	AGR	- Agricultural Supply
		IND	- Industrial Service Supply
PROC	- Industrial Process Supply	GWR	- Ground Water Recharge
POW	- Hydropower Generation	REC-1	- Water Contact Recreation
REC-2	- Non-Water Contact Recreation	WARM	- Warm Freshwater Habitat
COLD	- Cold Freshwater Habitat	WILD	- Wildlife Habitat
X	- Present or Potential Beneficial Use	I	- Intermittent Beneficial Use

Table 7-30. Water Quality Data and Objectives for CRWQCB Municipal Water Supplies for Seven Oaks Dam (#) 1980-1986.

Water Quality Parameter	Unit	Number of Samples	Mean Concentration	Range of Values	CRWQCB Objectives
Temperature	Deg. C	6	15	26-7.5	32.2/25.5(1)
DO	mg/l	70	9.9	12.5-8.2	6+(2)
pH	-	71	8.13	8.7-6.7	8.5-6.5
TDS	mg/l	70	144	232-82	300
Hardness	mg/l	70	83	99-54	190
Sodium	mg/l	3	14.3	15-14	30
Chloride	mg/l	70	4.84	8-0	20
Nitrogen (N)	mg/l	1	1.80**	1.80**	5
Sulfate	mg/l	70	11.50	41-4	60
BOD-5 (filter)	mg/l	1	0.70	0.70	8
COD (filter)	mg/l	1	12.90	12.9	25

(#) Data compiled from U.S.G.S. gauge 11051500 and CRWQCB gauge Y517000 and Y5197800.

(1) Period for June through October/Rest of the Year - Warm Water Objective.

(2) Cold Water Objective.

(**) Data 1970-1980.

Table 7-31. Additional Water Quality Data and Objectives for CRWQCB Municipal Water Supplies for Seven Oaks Dam Including Prohibited Substances (#) 1980-1986.

Water Quality Parameter	Unit	Number of Samples	Mean Concentration	Range of Values	CRWQCB Objective
* Arsenic	ug/l	4	0	0	50
Barium	ug/l	4	0	0	1000
Boron	ug/l	2	0	0	750
Cadmium	ug/l	4	2.5	10-0	10
Chlorine	ug/l	-	-	-	100
* Chromium	ug/l	4	0	0	50
Cobalt	ug/l	15	67	120-0	200
Copper	ug/l	4	0	0	20
Cyanide	ug/l	-	-	-	200
Fluoride	ug/l	1	500	500	1000
Iron	ug/l	4	40	110-10	300
* Lead	ug/l	4	0	0	50
Manganese	ug/l	4	7.5	10-0	50
* Mercury	ug/l	14	1.2**	12-0**	2
Selenium	ug/l	4	0	0	10
Silver	ug/l	-	-	-	50
Zinc	ug/l	20	39**	280-0**	100
Fecal Colif.	30-day	3	377	240-540	200/100ml(3)
Ammonia (UIA)	ug/l	11	2.2	13.3-0**	25(1)
Nitrate (NO3)	mg/l	1	0.4	0.4	45
Methyl. Blue	mg/l	1	0.12	0.12	0.5
* DDT	ug/l	17	0.084**	1.4-0**	0.001(2)
* Dieldrin	ug/l	17	0**	0**	0.0019(2)
* Heptachor	ug/l	17	0**	0**	0.0038(2)
* Parathion	ug/l	16	0**	0**	0.04(2)
* PCB	ug/l	12	0**	0**	0.001(2)
* Toxaphene	ug/l	3	0**	0**	0.005(2)
* 2,4-D	ug/l	17	0.049**	0.84-0**	NONE

\# Data compiled from U.S.G.S. gauge 11051500, and CRWQCB gauges Y517000 and Y5197800.
* Direct discharge is prohibited.
(1) Cold Water Objective.
(2) EPA Standard for aquatic life.
(3) Fecal Coliform: Log mean less than 200/100 ml based on 5 or more samples/30-day period, not more than 10 percent of the samples exceed 400/100 ml for any 30-day period.
(**) Data 1971-1982.
(UIA) Un-ionized.

Table 7-32. Water Quality Data and Objectives for CRWQCB Municipal Water Supplies for Prado Dam 1980-1986.

A.

Santa Ana River	Total Dissolved Solids mg/l	Hardness mg/l	Sodium mg/l	Chloride mg/l	Total Nitrogen as N mg/l	Sulfate mg/l	Filtered BOD mg/l	Filtered COD mg/l
(1) Downstream	650	---	---	---	---	---	---	---
(2)	641	297	93	110	7.9	131	2.6**	45
(1)* Upstream	700	350	110	140	10.0	150	10.0	30
(2)	602	329	186***	91	---	453***	---	---

(1) CRWQCB Objective (baseflow).
(2) Mean Concentrations of Observed Samples.
(*) Compiled from U.S.G.S. gauge 11066460 and CRWQCB gauge Y6141000.
(**) Data 1970-1980.
(***) Less than 5 samples.

B.

Water Quality Parameter	Unit	Observed Mean Concentration Upstream	Observed Mean Concentration Downstream	CRWQCB Objective Lower Limit	CRWQCB Objective Upper Limit
(1) Temperature	Deg. C	24.3/18.4	21.1/15.9	---	32.2/25.5
DO	mg/l	8.1	8.8	5.0	---
pH	---	7.9	7.8	6.5	8.5
(2) Fecal Colif.	30-day	---	483**	---	200/100 ml
Ammonia as N	mg/l	0.03**	0.04**	---	0.8
Chlorine	mg/l	---	---	---	0.1
Boron	mg/l	---	0.18	---	0.75
Copper	mg/l	0.08**	0.017	---	0.02
Zinc	mg/l	0.23**	0.059	---	0.10

(1) Period for June through October/Rest of the Year.
(2) Fecal Coliform: Log mean less than 200/100 ml based on 5 or more samples/30-day period, not more than 10 percent of the samples exceed 400/100 ml for any 30-day period.
(**) Data 1970-1980.

Table 7-33. Additional Water Quality Data and Objectives for CRWQCB Municipal Water Supplies for Prado Dam Including Prohibited Substances 1980-1986.

Water Quality Parameter	Unit	Number of Samples	Mean Concentration	Range of Values	CRWQCB Objective
* Arsenic	ug/l	31	4.71	10-2	50
Barium	ug/l	32	125	300-100	1000
Cadmium	ug/l	28	1.75	19-0	10
* Chromium	ug/l	28	9.82	40-0	50
Cobalt	ug/l	29	2.89	8-0	200
Cyanide	ug/l	7	2.85	10-0	200
Fluoride	ug/l	84	546	900-300	1000
Iron (in H_2O)	ug/l	32	24.3	130-3	300
* Lead	ug/l	29	28.7	520-2	50
Manganese	ug/l	32	262	830-80	50
* Mercury	ug/l	28	0.582	2.8-0	2
Selenium	ug/l	20	0.95	4-0	10
Silver	ug/l	33	0.515	5-0	50
Nitrate (NO3)	mg/l	19	23	49-4.2	45
Methyl. Blue	mg/l	24	0.224	0.43-0	0.5
* Chlordane	ug/l	30	0.5	0.10-0	0.01(1)
* DDT	ug/l	30	0.005	0.01-0	0.001(1)
* Dieldrin	ug/l	30	0.0053	0.01-0	0.0019(1)
* Heptachor	ug/l	30	0.0053	0.01-0	0.0038(1)
* Mirex	ug/l	30	0.005	0.01-0	0.001(1)
* Parathion	ug/l	31	0.0074	0.03-0	0.04(1)
* PCB	ug/l	30	0.053	0.10-0	0.001(1)
* 2,4-D	ug/l	31	0.113	0.36-0.02	NONE

* Direct discharge is prohibited.
(1) EPA Standard for aquatic life.

Table 7-34. Treatment Plant Waste Loads for 5-Year Period. (1980-85)

Treatment Plant	Flow MGD	TDS mg/l	Ammonia (NH3) mg/l	Total Nitrogen mg/l	Remarks
Riverside	28.3	650	14	20	---
Indian Hills	0.2	650	2	19	About 7 percent increase in TDS expected during the next ten years.
Norco/Cal.	1.8	700	14	17	Significant problem with TDS, 50 percent increase expected during the next ten years.
Corona	1.8	700	10	19	About 21 percent increase in TDS expected during the next ten years.
Chino Basin R.P. 1	23.4	515	10	22	TDS not considered a problem - less than 6 percent increase expected during the next ten years.
Chino Basin R.P. 2	4.9	610	13	21	About 8 percent increase in TDS expected during the next ten years.

Table 7-35. Flood Peak Discharges Along the Lower Santa Ana River, Local Storm With Future Conditions.

Location	Local 100-Year Storm Peak Discharge[2] (ft^3/s)	Local Standard Project Storm Discharge[2] (ft^3/s)
Prado Dam Outflow	5,000	5,000[1]
Downstream of:		
Wardlow Canyon	7,500	9,000
Weir Canyon	17,800	27,000
Imperial Highway	18,700	28,000
Carbon Canyon Diversion	21,400	33,800
Santa Ana Freeway	22,200	35,200
Santiago Creek	25,700	38,600
Hamilton Avenue	25,700	38,600
Pacific Ocean	26,500	39,400

(1) Assumed outflow discharge from Prado Dam.

(2) These are not design discharges. Design discharges are from a general storm with Prado Dam releasing 30,000 ft^3/s.

See plates 7-7 through 7-10 for locations.

Table 7-36. 100-Year Design Peak Discharges for Side Drains in Santa Ana River (From Prado Dam to Pacific Ocean).

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
XA1	(3.10)		STA 1603+10	L			2200			Wardlow Wash
XA2	(0.40)						460			Between Prado Dam and confluence with Prado Dam
XA3	(2.10)		STA 1603+10	L			1500			Fresno Canyon
XB1	(10.60)		STA 1535+80	R	Natural Channel		6800			Aliso Canyon
XB2	(1.20)			R			910			
XB3	(1.00)						*			Q_{100} = 940 ft^3/s
			STA 1592+80	L	72"	CMP	490*			
			STA 1588+40	L	54"	CMP	370			
XC1	(0.07)		STA 1503+20	L	42"	RCP	80			Trailer Park near Railroad Track
XD	(0.75)			R			1000			
XC	(0.65)		STA 1497+40	L		Fwy. Culvert	590			
XB	(0.54)						*			Q_{100} = 550 ft^3/s
			STA 1487+50	L	36"	CMP	150			
			STA 1484+20	L	54"	CMP	240			
			STA 1482+10	L	12"	CMP	50			
			STA 1478+30	L	24"	CMP	110			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25}	/ Q_{10}	Remarks
			STA 1477+50	L	54"	RCP					
			STA 1474+20	L	24"	RCP					
			STA 1471+70	L	30"	RCP					
			STA 1463+60	L	48"	RCP					
			STA 1458+90	L	48"	RCP					
			STA 1450+20	L	36"	RCP					
			STA 1444+30	L	36"	RCP					
			STA 1440+40	L	36"	RCP					
XA	(2.13)		STA 1427+80	L	Natural Channel		*				Q_{100} = 2700 ft^3/s Coal Canyon
XE	(0.77)			L			*				Q_{100} = 750 ft^3/s
			STA 1371+90	L	60"	RCP					
			STA 1367+50	L	60"	RCP					
			STA 1364+60	L	18"	CMP					
			STA 1358+20	L	18"	CMP					
			STA 1352+30	L	60"	RCP					
XH	(2.40)			R			*				Q_{100} = 2700 ft^3/s
	0.07		STA 1415+00	R	Prop. 42"	RCP	160		97		(E01P360)
	1.56		STA 1390+00	R	Prop Rect Channel		1910		1546		(E01S20)
XI	(0.74)			R			*				Q_{100} = 1000 ft^3/s
	0.38		STA 1359+60	R	78"	RCP	510		84		(E01P21) (Prop. 42" RCP)
	0.36		STA 1338+00	R	72"	RCP	510			330	(E01P20)

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25}	/ Q_{10}	Remarks
XF	(5.28)		STA 1338+50	L	Natural Channel		*				Q_{100} = 5800 ft^3/s (Gypsum Canyon)
XJ	(1.11)			R			*				Q_{100} = 1400 ft^3/s
			STA 1315+10	R	90"	RCP	1400	1140			(E01S19)
			STA 1313+20	R	48"	RCP					Lost Trough Canyon
			STA 1319+20	R	18"	RCP					
XK	(1.72)			R			*				Q_{100} = 2300 ft^3/s
	0.14		STA 1296+70	R	48"	RCP	190			231	(E01P31)
			STA 1289+40	R	27"	RCP					
XG	(1.16)			L			*				Q_{100} = 1300 ft^3/s
			STA 1300+70	L	54"	RCP					
			STA 1298+30	L	24"	PIPE					
			STA 1293+70	L	48"	RCP					
			STA 1280+80	L	36"	CMP					
XK	(1.72)			R			*				Q_{100} = 2300 ft^3/s
			STA 1267+30	R	36"	RCP					
	0.07		STA 1259+80	R	42"	RCP	100			116	
			STA 1255+40	R	36"	RCP					
			STA 1246+80	R	27"	RCP					
	0.59		STA 1244+70	R	84"	RCP	780			635	(E01P29)
	0.09		STA 1240+90	R	30"	RCP	130			136	

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25}	Local Agency Q_{10}	Remarks
	0.07		STA 1237+40	R	60"	RCP	100			105	
			STA 1232+10	R	48"	RCP					
	0.50		STA 1230+80	R	27"	RCP	670			480	(E01P28)
			STA 1225+70	R	60"	RCP	670			480	
A	(0.84)			R			*				Q_{100} = 1200 ft^3/s
	0.50	1	STA 1206+90	R	13.5'x 8'	RCB	680			480	(E01P28)
	0.25	2	STA 1202+04	R	66"	RCP	360			251	(E01P27)
	0.09	3	STA 1189+90	R	72"	RCP	80				Park Area
		4	STA 1189+80	R	72"	RCP	80				
C	(4.41)			R			*				Q_{100} = 4500 ft^3/s
		5	STA 1186+90	R	48"	CMP	60				
		6	STA 1184+95	R	48"	CMP	60				
		7	STA 1184+20	R	48"	CMP	60				
		8	STA 1184+00	R	48"	CMP	60				
		9	STA 1183+25	R	48"	CMP	70				
		10	STA 1183+00	R	48"	CMP	70				
		11	STA 1182+10	R	48"	CMP	60				
	1.61	12	STA 1181+90	R	48"	CMP	60				(E06S01)
	2.74	13	STA 1180+80	R	8.5'x19'	RCB	4000				(E06)
B	(1.89)			L			*				Q_{100} = 2600 ft^3/s
		14	STA 1211+10	L	8'x9.5'	RCB	1100				(Weir Canyon Road)
		15	STA 1202+20	L	8'x8'	RCB	1050				(E01P54)
		16	STA 1184+50	L	60"	RCP	430				
		17	STA 1171+90	L	24"	CMP	20				(Caltrans)

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
D	(1.22)			L			*			$Q_{100} = 1520\ ft^3/s$ (E01S13)
		18	STA 1166+60	L	24"	RCP	20			
		19	STA 1163+00	L	(2)-8'x5'	RCB	700			
		20	STA 1157+90	L	(2)-6'x5'	RCB	800			
G1	(0.59)			L			*			$Q_{100} = 840\ ft^3/s$
		21	STA 1154+40	L	24"	RCP	15			
		22	STA 1150+90	L	24"	RCP	15			
		23	STA 1145+90	L	24"	RCP	15			
		24	STA 1134+70	L	8'x6'	RCB	780			
		25	STA 1124+40	L	24"	RCP	15			
G2	(0.79)			L			*			$Q_{100} = 1120\ ft^3/s$
		26	STA 1114+90	L	(2)-8'x8'	RCB	1100			
		27	STA 1105+90	L	24"	RCP	20			
ED	(0.10)			R				*		$Q_{100} = 125\ ft^3/s$
		28	STA 1174+95	R	48"	CMP	40			
		29	STA 1169+00	R	72"	CMP	40			
		30	STA 1168+90	R	72"	CMP	45			
E	(0.55)			R			*			$Q_{100} = 650\ ft^3/s$
		31	STA 1148+95	R	24"	RCP	30			
		32	STA 1148+95	R	102"	RCP	620			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
FG	(0.35)			R			*			Q_{100} = 650 ft^3/s
		33	STA 1146+50	R	66"	CMP	60			
		34	STA 1141+00	R	72"	CMP	70			
		35	STA 1113+90	R	39"	RCP	60			
		36	STA 1124+97	R	66"	CMP	60			
		37	STA 1114+20	R	66"	CMP	60			
		38	STA 1099+20	R	54"	RCP	100			
		39	STA 1095+30	R	(3)-72"	CMP	240			
F	(0.87)			R			*			Q_{100} = 1040 ft^3/s
		40	STA 1130+50	R	72"	RCP	400		274	(E01P73)
		41	STA 1130+50	R	42"	RCP	60		274	(E01P73)
		42	STA 1116+70	R	60 & 84"	RCP	580		132	(E01P22)
JJ	(0.10)			R						Q_{100} = 130 ft^3/s
		43	STA 1076+40	R	36"	RCP	40			
		44	STA 1075+70	R	54"	RCP	90			
H	(2.54)			L			*			Q_{100} = 2250 ft^3/s (Walnut Canyon)
		45	STA 1096+40	L	(3)-12x7'	RCB	2250			
L1A	(1.14)			L						Q_{100} = 1233 ft^3/s (E01P13)
		46	STA 1075+00	L	(3)-8'x7'	RCB	1233			
L1B	(0.15)						*			Q_{100} = 100 ft^3/s
		47	STA 1065+80	L	24"	RCP	30			
		48	STA 1062+30	L	48"	RCP	70			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
I	(0.35)			R			*			Q_{100} = 550 ft^3/s (E01014)
		49	STA 1066+50	R	8'x 6'	RCB	550			
K	(2.72)			R			*			Q_{100} = 2300 ft^3/s (E01S01)
	2.68	50	STA 1059+90	R	20'x11.5'	RCB	2300	1716		
			STA 1046+50	R	30"	RCP				
L2	(0.61)			L			*			Q_{100} = 600 ft^3/s
		51	STA 1046+70	L	54"	RCP	460			
		52	STA 1037+90	L	54"	RCP	140			
L3	(0.48)			L			*			Q_{100} = 640 ft^3/s
		53	STA 1029+20	L	PROP. 42"	RCP	430			
			STA 1029+20	L	54"	RCP				
		54	STA 1021+95	L	12"	STL	15			
		55	STA 1013+60	L	18"	CMP	15			
		56	STA 1007+40	L	(4)-48"	RCP	180			
L4	(0.44)			L			*			Q_{100} = 600 ft^3/s
		57	STA 994+70	L	(2)-60"	RCP	440			
		58	STA 990+90	L	(2)-30"	CMP	60			
		59	STA 984+50	L	48"	RCP	100			
NL	(0.35)			R			*			Q_{100} = 360 ft^3/s
		60	STA 1046+50	R	30"	RCP	30			(Downstream of Imperial Hwy)
		61	STA 1031+30	R	DIV.	WORKS	30			
		62	STA 1030+40	R	(4)-36"	CMP				O.C.W.D. (Diversion Dike)
		63	STA 1019+10	R	72"	RCP	280			Drain into spreading ground

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
		64	STA 1019+05	R	36"	RCP	50			
		65	STA 979+50	R	(4)-36"	CMP				(Downstream of Lakeview Ave.) Division Works
L5	(0.63)			L			*			Q_{100} = 900 ft^3/s
		66	STA 978+40	L	42"	RCP	60			
		67	STA 975+65	L	18"	CMP	20			
		68	STA 970+60	L	24"	RCP	20			
		69	STA 965+85	L	10'x6'	RCB	720			Deerfield Channel (E01S04)
		70	STA 958+30	L	42"	CMP	80			
L6	(0.50)			L			*			Q_{100} = 750 ft^3/s
		71	STA 955+10	L	24"	CMP	20			
		72	STA 948+65	L	42"	CMP	80			
		73	STA 938+65	L	42"	RCP	170			
		74	STA 928+50	L	54"	RCP	480			
NL6	(0.32)			R			*			Q_{100} = 510 ft^3/s Upstream of R. Freeway (Caltrans) O.C.W.D.
		75	STA 916+25	R	DIV. (4)-36"	WORKS 510				
L7A	(0.58)			L		*				Q_{100} = 870 ft^3/s
		76	STA 926+45	L	60"	CMP	200			
		77	STA 923+75	L	36"	RCP	40			
		78	STA 923+05	L	18"	RCP	20			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
		79	STA 907+85	L	(2)-48"	RCP	200			
		80	STA 898+00	L	48" & 42"	RCP	140			
		81	STA 871+10	L	60	RCP	270			Glassell Street
OP1	(0.03)			R			*			
		82	STA 893+90	R	(4)-24"	CMP				(O.C.W.D.) (Diversion Works)
		83	STA 852+15	R	(4)-36"	RCP				(Upstream of Carbon Cyn. Div.)
N6+M2+N	(14.90)						*			Q_{100} = 5300 ft^3/s (E02) (Carbon Cyn. Div.)
		84	STA 846+25	R	TRAP.	CHANNEL	5300			
OP2	(0.07)									Q_{100} = 114 ft^3/s
		85	STA 844+45	R	DIV.	WORKS				(O.C.W.D.)
		86	STA 844+25	R	(4)-36" (2)-36"	CMP				(Diversion Works)
		87	STA 813+80	R	DIV.	WORKS				O.C.W.D.
		88	STA 709+20	R	42"	RCP	114			
P	(1.62)						*			Q_{100} = 1800 ft^3/s (E10)
		89	STA 805+35	L	30"	RCP	23			Fletcher Brent-
		90	STA 799+95	L	36"	CMP	33			Wood Channel

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
		91	STA 797+40	L	42"	RCP	40			
		92	STA 788+05	L	(2)-7'x7'	RCB	1700	1050		
Q	(0.32)						*			Q_{100} = 400 ft^3/s (01S03)
		93	STA 763+50	L	66"	RCP	400	250		
OPP	(0.01)	94	STA 830+20	L	24"	CMP	20			Q_{100} = 20 ft^3/s
S	(0.39)						*			Q_{100} = 200 ft^3/s
		95	STA 749+75	L	16"	CMP	6			
		96	STA 748+15	L	54"	RCP	34			(Near Ball Road)
		97	STA 740+35	L	42"	RCP	100			
		98	STA 724+80	L	14"	ACP	20			
		99	STA 710+00	L	27"	RCP	40			
O	(2.03)						*			Q_{100} = 1400 ft^3/s (Downstream of Ball Upstream of SPRR)
		100	STA 747+90	R	12'x9.5'	RCB	1400			(Drains into spreading ground) (E01S02)
R	(4.90)						*			Q_{100} = 3700 ft^3/s (E07), Collins Channel
		101	STA 699+20	L	(2)-12x12'	RCB	3700			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
UU	(0.15)						*			Q_{100} = 230 ft^3/s (Trailer Park) (O.C. Road Dept.)
		102	STA 735+10	R	12'x12'	RCB	70			(City of Anaheim)
		103	STA 688+60	R	36"	CMP	160			Q_{100} = 310 ft^3/s
		104	STA 686+30	R	48"	RCP				
TT	(1.53)						*			
	0.091	105	STA 695+70	L	48"	RCP	60			
		106	STA 682+70	L	24"	RCP	20			
	0.115	107	STA 669+70	L	48"	RCP	110			
	0.059	108	STA 659+00	L	48"	RCP	110			
		109	STA 654+40	L	18"	CMP	10			
T	(1.53)						*			Q_{100} = 1400 ft^3/s (E11) Bitterbush Ch.
	1.53	110	STA 628+60	L	TRAP. (2) 12'x9'	CHANNEL RCB	1400			
V	(0.56)						*			Q_{100} = 620 ft^3/s (Between Garden Grove Freeway and Santa Ana Freeway Drain) (Freeway Drain at Location 112)
		111	STA 625+90	L	48"	RCP	70			
		112	STA 625+55	L	(3)-5'x5'	RCB	400			
		113	STA 621+10	L	(6)-2'x3'	RCB	130			
		114	STA 605+10	L	24"	CMP	20			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
U	(2.61)						*			Q_{100} = 1600 ft^3/s (E12)
	2.61	115	STA 643+40	R	10'x11'	RCB	1600			(St. College Blvd. & Anaheim Stadium)
UV	(0.16)						*			Q_{100} = 265 ft^3/s (Caltrans)
		116	STA 627+10	R	(2)-30"	CMP	50			
		117	STA 620+60	R	42"	CMP	89			
	0.16	118	STA 607+20	R	42"	RCP	106			
		119	STA 607+10	R	24"	CMP	20			
UVU	(0.11)						*			Q_{100} = 190 ft^3/s (Freeway Drain)
		120	STA 600+75	R	36"	RCP	40			
		121	STA 600+30	R	36"	RCP				
	0.118	122	STA 583+20	R	54"	RCP	80			
		123	STA 583+30	R	30"	RCP	30			
WV4	(0.04)	124	STA 583+50	L	24	RCP	90			Q_{100} = 90 ft^3/s
W	(102.7)	(SANTIAGO CREEK BASIN)					*			Q_{100} = 5000 ft^3/s (After Santiago Creek Reservoir)
		125	STA 566+00	L		Trap. Ch.	5000			(Santiago Creek)
WVI	(0.12)						*			Q_{100} = 210 ft^3/s
		126	STA 560+85	L	48"	RCP	100			
		127	STA 554+00	L	30"	CMP	30			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
WV5	(0.11)						*			Q_{100} = 52 ft^3/s
		128	STA 536+65	R	36"	CMP	52			
WV	(0.64)						*			Q_{100} = 400 ft^3/s
		129	STA 528+40	R	36"	RCP	55			
		130	STA 522+40	R	36"	RCP	15			
		131	STA 509+35	R	60"	RCP	280			
		132	STA 498+35	R	36"	RCP	50			
WV2	(1.21)						*			Q_{100} = 930 ft^3/s
		133	STA 554+90	L	24"	CMP	100			
		134	STA 534+55	L	58"x36"	ARCH P.	120			
		135	STA 523+70	L	24"	RCP	30			
		136	STA 529+40	L	30"	RCP	40			
		137	STA 523+10	L	(3)-48"	RCP	750			
WV3	(0.83)						*			Q_{100} = 1400 ft^3/s (Fairview St.)
		138	STA 503+65	L	(2) 10'x5'	RCB	75			
WV6	(0.34)						*			Q_{100} = 100 ft^3/s (South of Fairview Street)
		139	STA 490+00	L	48"	RCP	100			
WVX	(0.03)			R			*			Q_{100} = 60 ft^3/s (Between McFadden & Edinger Avenue)
		140	STA 399+70	R	30"	RCP	60			

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25}	/ Q_{10}	Remarks
X1	(0.39)			R			*				Q_{100} = 380 ft^3/s (E01P02)
	0.078	141	STA 353+65	R	(2)-24"	RCP-F.G.	75				Vol = 42 ac-ft
	0.305	14	STA 352+40	R	60"	RCP W/F.G.	305				Pumping Station at Harbor and Warner
X3	(0.40)						*				Q_{100} = 515 ft^3/s
		143	STA 208+10	R	24"	RCP-F.G.	15				
	0.398	144	STA 159+10	R	(3)-36"	RCP W/F.G.	500		264		Vol = 43 ac-ft Pump Station at Meredith
					(2)-36"	ADDITIONAL REQUIRED					
X2	(0.788						*				Q_{100} = 810 ft^3/s
	0.80	145	STA 91+05	R	(4)-42"	RCP-F.G.	810		552		Vol = 85 ac-ft Pumping Station at Hamilton
					(2)-42"	ADDITIONAL REQUIRED					
GV3	(7.47)			R	Trap.	CHANNEL	*				Q_{100} = 4400 ft^3/s
		146	STA 189+90	L	42"	RCP	92				Greenville-Banning Channel
	0.097	147	STA 182+55	L	42"	RCP	81				
	0.082	148	STA 174+55	L	42"	RCP	68				(D03)
		149	STA 166+45	L	36"	RCP	67				
		150	STA 159+80	L	30"	RCP	55				
(Recommended a Pump Station for Drains 146-150)											Q=363 CFS, Volume=24 Ac-Ft Proposed Pump Sta.

Table 7-36. (Continued)

Subarea Name	Drainage Area* mi^2	Drain No.	CL Channel Station	Bank	Drain Size	Type of Drain	Discharge in ft^3/s COE Q_{100}	EMA Q_{25}	Local Agency Q_{25} / Q_{10}	Remarks
GV4	(2.37)	151	STA 152+90	L	Trap.	CHANNEL	2400			Q_{100} = 2400 ft^3/s (D04)
GV5	(0.60)									Q_{100} = 530 ft^3/s
GV3+GV4 +GV5	(10.44)	152	STA 83+00	L	Rect. Ch.		*			Q_{100} = 5800 ft^3/s Greenville-Banning Channel (D03 + D04)

* Drainage area in parenthesis is for the entire subarea. Others denote a portion of the total subarea drainage area.

Table 7-37. Pertinent Information on Side Drainage Investigation, Oak Street Drain.

Left Bank

Subarea			Side-Drainage Requirements				
Drain No.*	Size (mi^2)	Discharge Peak** (ft^3/s)	Drain Capacity (ft^3/s)	Description Existing	Description Proposed	Station	Remarks
2	0.004	4.0	8.0	18" RCP	--	204+30	Connect to Existing Drain
5	0.03	25	9.0	8" CI	--	161+70	Connect to Existing Drain
6	0.08	60	62.0	--	5-B***	161+50	Provide Stub for 33" RCP
8	0.003	2.5	0.9	8" PVC	--	161+30	Connect to Existing Drain
10	0.10	80	160	--	5-A***	130+20	Provide Stub for 60" RCP
13	2.12	1700	1700	18' Wide Rect-angular Channel		112+06	Mangular Channel
15	0.11	88	8	12" CMP	--	90+60	Connect to Existing Drain and Provide for a 42" RCP
16	0.004	4	8	12" CMP	--	90+60	Connect to Existing Drain
21	0.040	40		--	48" RCP	65+80	Provide for Street Drain
22	0.006	5	15	18" CMP	--	61+00	Connect to Existing Drain
23	0.008	7	20	Grate in Bridge Deck	Catch Basin	60+00	Provide Stub Form
24	0.003	3	20	Grate in Bridge Deck	Catch Basin	59+75	Provide Stub Form
26	0.04	30	--	--	5E***	40+70	Provide Stub for Trap Ch.
27	0.037	28	10	None	27" RCP	16+00	Provide Grated Drain Through Levee

*Locations of Side Drains Shown on Plan and Profile Sheets, Volume 5, Chapter IV, Hydraulic Design.
**25-Year Peak Discharges for Side Drains and 100-Year Peak Discharge for Mangular Channel Confluence.
***Proposed by the city of Corona.

Table 7-37. (Continued)

Right Bank

Subarea			Side-Drainage Requirements				
Drain No.*	Size (mi^2)	Discharge Peak** (ft^3/s)	Drain Capacity (ft^3/s)	Description Existing	Description Proposed	Station	Remarks
1	0.004	4.0	8.0	18" RCP	--	204+30	Connect to Existing Drain
3	0.09	72	55.0	36" CMP	5-C***	169+00	Provide Addntl Stub for 30" RCP and Connect to Existing Drain
4	0.003	2.5	4.50	12" CMP	--	161+70	Connect to Existing Drain
7	0.002	2.0	3.0	8" PVC	--	161+30	Connect to Existing Drain
9	0.04	45	100	36" RCP	--	138+50	Connect to Existing Drain
11	2.51	2400	0	--	Lincoln Diver-sion Line 3	124+00 to 122+30	Provide Con-fluence for 10' Wide Rec-tangular Con-crete Channel. Excess Flow Will Enter Lincoln Div. Line 3
12	0.07	60	55	60" RCP	--	117+50	Connect to Existing Drain
14	0.01	9	15	18" RCP	--	106+30	Connect to Existing Drain
17	0.03	22	22	Street Drain	--	85+00	Provide Inlet for Street Flow

Table 7-37. (Continued)

Right Bank

Subarea			Side-Drainage Requirements				
Drain No.*	Size (mi^2)	Discharge Peak** (ft^3/s)	Drain Capacity (ft^3/s)	Description Existing	Description Proposed	Station	Remarks
18	0.01	8	8	Concrete Swale	--	80+00	Provide Inlet for Street Flow
19	0.019	20	20	--	30" RCP	78+30	Provide Inlet for Street Flow
20	0.15	170	168	72" RCP	Line 8	74+30	Connect to Existing Drain. Excess Flow Will Enter Channel over top of Wall
25	0.005	4	10	12" SQ RC Conduit	--	41+50	Connect to Existing Drain

*Locations of Side Drains Shown on Plan and Profile Sheets, Volume 5, Chapter IV, Hydraulic Design.
**25-Year Peak Discharges for Side Drains and 100-Year Peak Discharges for Lincoln Diversion Confluence.
***Proposed by the City of Corona.

Table 7-38. Peak Discharges for Interior Drainage of Prado Dikes.

Subarea Name	Drainage Area (mi^2)	SPF (Local Storm) Peak (ft^3/s)	SPF (Local Storm) Volume (ac-ft)	Subarea Runoff 100-Yr. Flood (Local Storm) Peak (ft^3/s)	Subarea Runoff 100-Yr. Flood (Local Storm) Volume (ac-ft)	SPF (General Storm) Peak (ft^3/s)	SPF (General Storm) Volume (ac-ft)
A_1-A_5 - Santa Fe (A.T. & S.F.) Railroad Tracks	0.40	950	60	550	35	50	47
"B"- Corona Sewage Plant	0.12	320	18	180	10	20	14
"C"- Alcoa Aluminum Plant	0.44	1020	69	590	40	60	58
"D"- Corona N.H. Tract	0.14	380	21	220	12	20	22
"E"- California Institute for Women	0.39	790	58	460	33	50	50

See plate 7-73 for locations.

Table 7-39. Coincident Water Surface Elevation in Prado Dam with Peak Discharges at Interior Dikes.

Combined Events			
Interior Dike Runoff	Prado Dam Inflow	Coincident W.S.E. in Prado w/Peak Discharge at Interior Dike, NGVD	Equivalent Filling Frequency in Prado Dam, Yrs.
SPF General Storm	RDF General Storm	542.50	75-Year
100-Year Flood Local Storm	100-Year Flood General Storm	538.00	50-Year
SPF Local Storm	SPF General Storm	544.00	85-Year

Table 7-40. Pertinent Side Drain Data, Santiago Creek.

RIGHT BANK									
	SUBAREA				SIDE-DRAINAGE REQUIREMENTS				
Drain No.	Name*	D.A. mi^2	100-Yr Q-Peak ft^3/s	Total Q ft^3/s	Design Capacity ft^3/s	Description	Station**	Remarks	Disposition of Excess Flow
1	F3	0.40	293	293	+	Stubout for 18" RCP	289+80	Very localized drainage.	Not required.
2					+	Stubout for 18" RCP	285+50	Very localized drainage.	Not required.
3					20	Stubout for 18" RCP+ 40-foot grouted rock spillway from Sta. 280+80 to 281+20	282+20		13 ft^3/s to spillway.
4					273	Stubout for 66" RCP	265+15	No excess flow.	Not required
6	H2	0.20	208	78	78	Stubout for 24" RCP+ 40-foot grouted rock spillway from Sta. 58+30 to 58+70	58+30		63 cfs to spillway.
8	H1	0.37	283	283	20	Stubout for 18" RCP	36+60	Excess flows drain W. in River Lane to Drain 11.	13 ft^3/s to spillway.
9					24	Stubout for 18" RCP	32+80	DO.	6 ft^3/s to U/S Bristol St.
10					24	Stubout for 21" RCP	30+90	DO.	
11					180	Stubout for 66" RCP+ 200-foot grouted rock spillway from Sta. 29+60 to 31+60	29+70	Excess flows from Drains 8, 9, 10, and 11 drain to U/S side Bristol Street.	65 ft^3/s to spillway.
13					59	Stubout for 30" RCP+ 40-foot grouted rock spillway from Sta. 14+50 to 14+90	14+30		32 ft^3/s to spillway.

*Subarea names are the same as shown on plate 7-5, numeric subscript indicates a sub-subarea name.
**Locations of side drains shown on Plan and Profile Sheets, Volume 5, Chapter IV, Hydraulic Design.

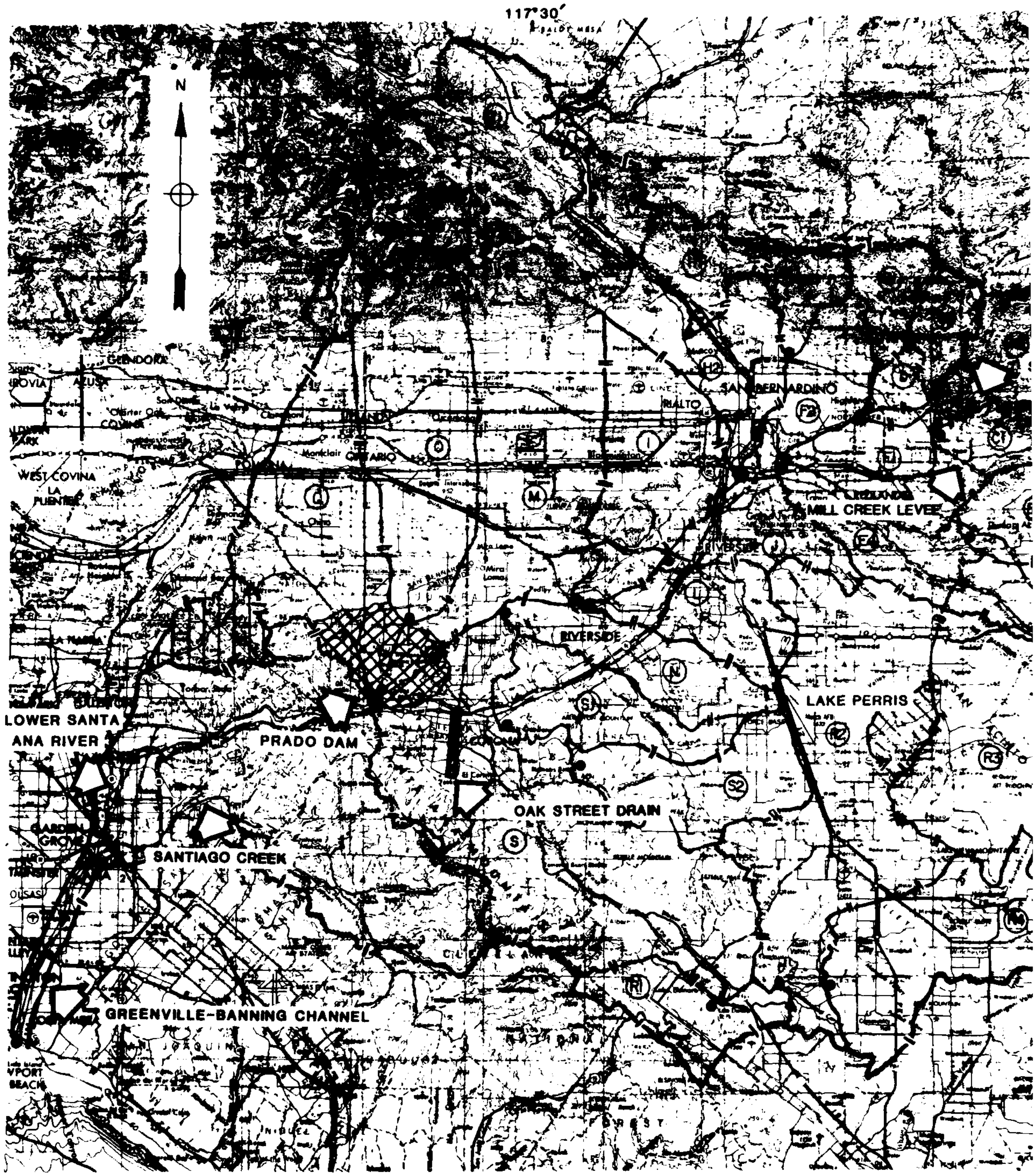
Table 7-40. (Continued)

LEFT BANK SIDE-DRAINAGE REQUIREMENTS									
	SUBAREA								
Drain No.	Name*	D.A. mi^2	100-Yr Q-Peak ft^3/s	Total Q ft^3/s	Design Capacity ft^3/s	Description	Station**	Remarks	Disposition of Excess Flow
5	F4	0.76	563	563	563	4'H x 4'W stubout for 3'H x 3.5'W trap. channel	296+30	Formal confluence required if drain is improved by local interests.	473 ft^3/s drains S.W. and enters exist. channel D/S of project limits. No spillway required.
7	H2	0.20	208	208	130	Stubout for 33" RCP	56+30		114 ft^3/s drains S. away from channel. No spillway required.
12	--	--	--	--	+	Stubout for 12" CMP	30+80	Very localized drainage.	Ground slopes away from channel. No spillway required.

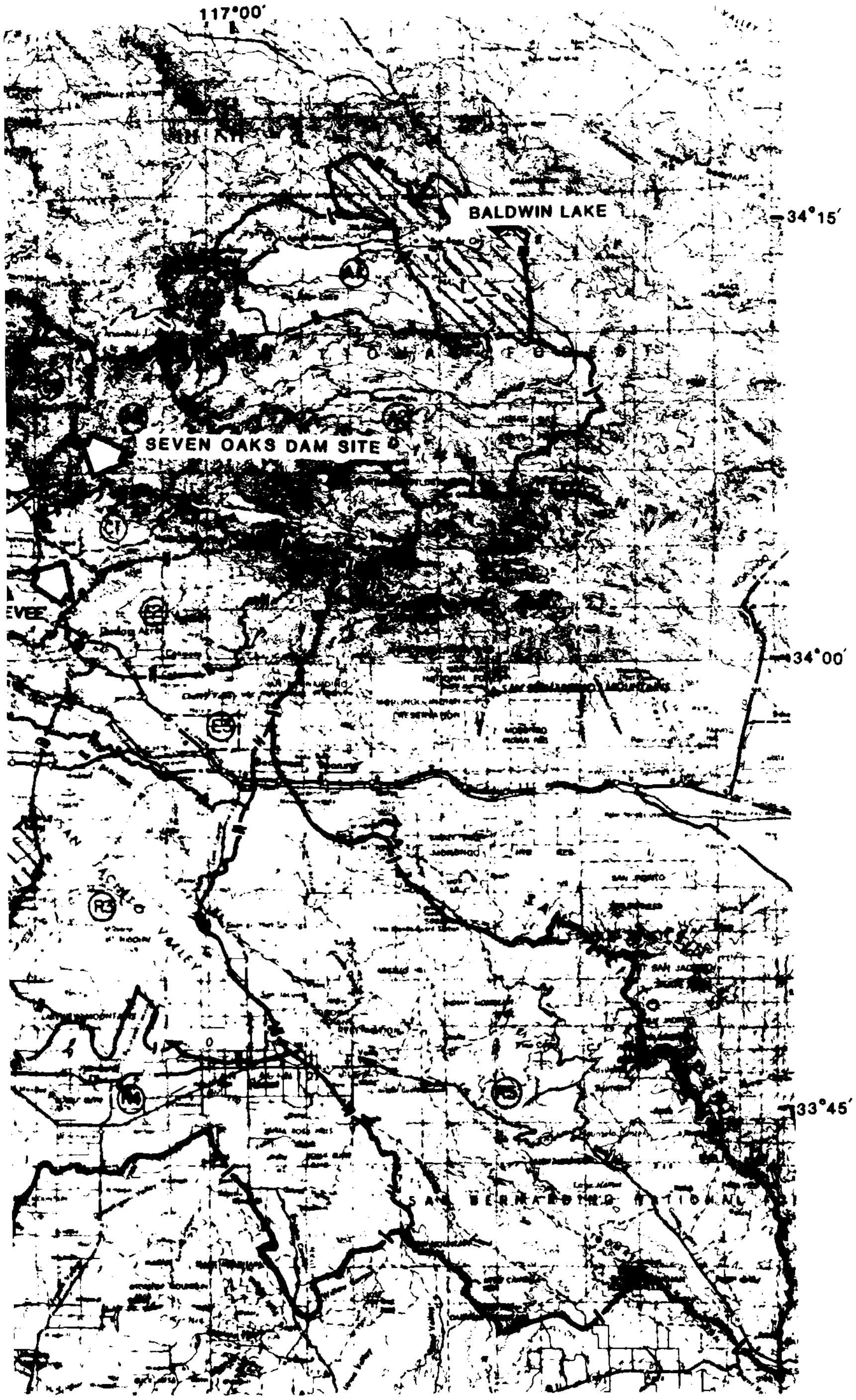
Table 7-41. Flood Risk Analysis.

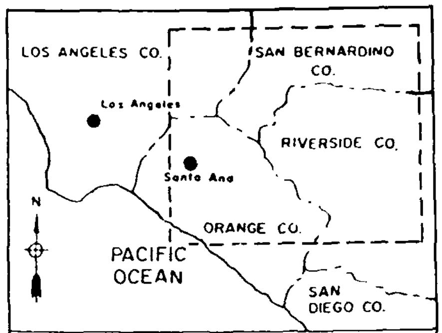
Period of Time (years)	Project Design Level Annual Exceedance Frequency (percent)	Risk of Exceeding Design Level (percent) One or More Floods	Risk of Exceeding Design Level (percent) Two or More Floods
Oak Street Drain, Santiago Creek and Lower Santa Ana River Interior Drainage: (100-Year Design)			
10	1.0	10	0
25	1.0	22	3
50	1.0	39	9
100 (project life)	1.0	63	26
Prado Dam, Mill Creek Levees, and Lower Santa Ana River Mainstem: (190-Year Design)			
10	approx. 0.5	5	0
25	approx. 0.5	12	1
50	approx. 0.5	22	3
100 (project life)	approx. 0.5	39	9
Seven Oaks Dam: (350-Year Design)			
10	approx. 0.29	3	0
25	approx. 0.29	7	0
50	approx. 0.29	14	1
100 (project life)	approx. 0.29	25	3

EXPLANATION OF THIS TABLE: If a project is designed to protect against a 100-year flood (1 percent chance event), during any 100-year period, a 63 percent risk exists that one or more floods will occur that exceed the design level. In other words, if 100 projects are designed to protect against a 100-year flood during any 100-year period, 63 of the projects will experience one or more floods exceeding the design level.



SEE TABLES 7-3





VICINITY MAP

AREA COVERED BY MAP

5 0 5 10 20 35

SCALE IN MILES

LEGEND

BOUNDARY OF DRAINAGE AREA

BOUNDARY OF SUBAREAS

BOUNDARY OF INEFFECTIVE AREA

(A) SUBAREA DESIGNATION

NON-CONTRIBUTING AREA

RESERVOIR POOL

NATURAL DRAINAGE IS TO THE SAN GABRIEL RIVER WITH A DIVERSION TO THE SANTA ANA RIVER

0 5 10 15

MILES

TABLES 7-3 THROUGH 7-5 FOR SUBAREA CHARACTERISTICS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

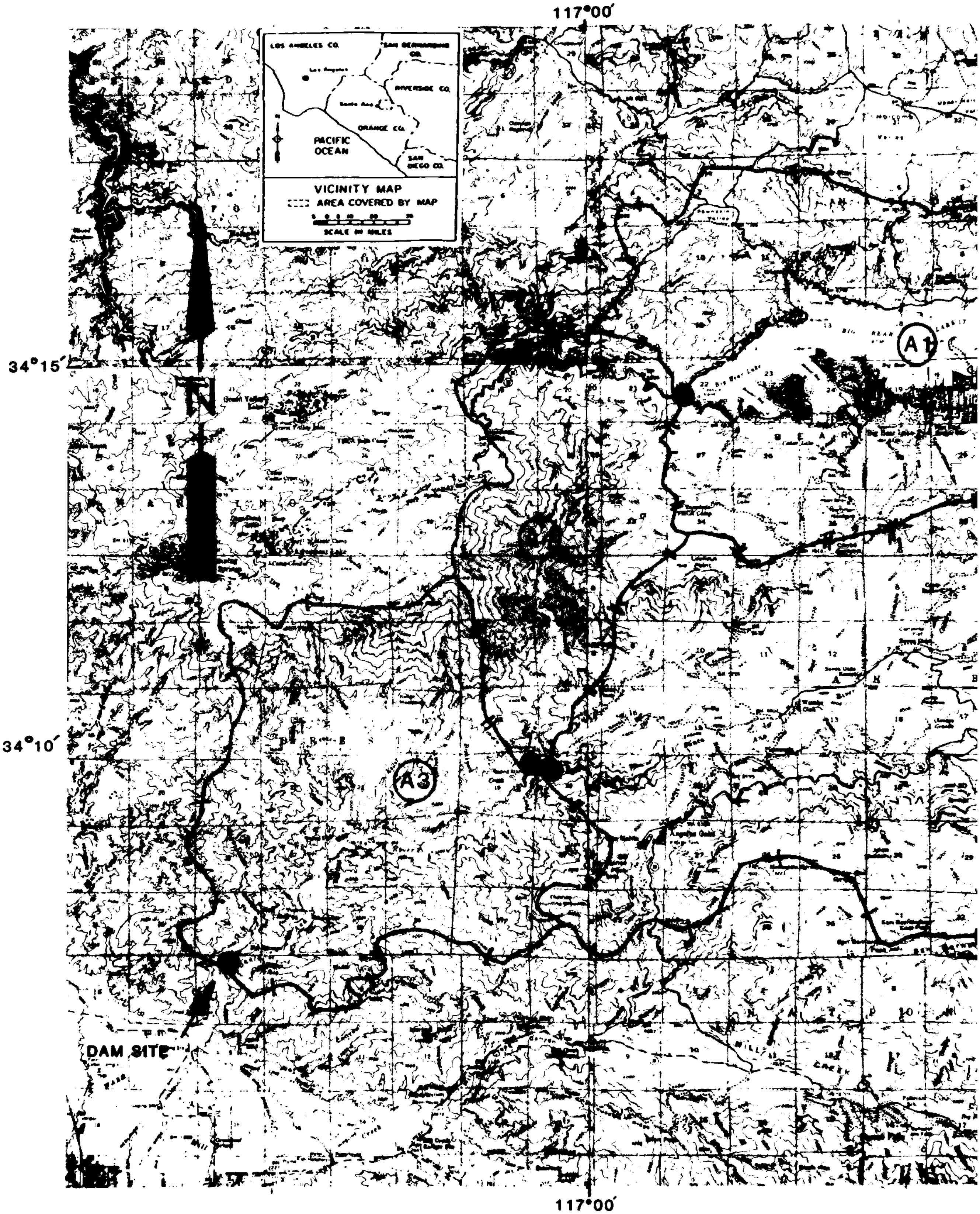
SANTA ANA RIVER DRAINAGE AREA

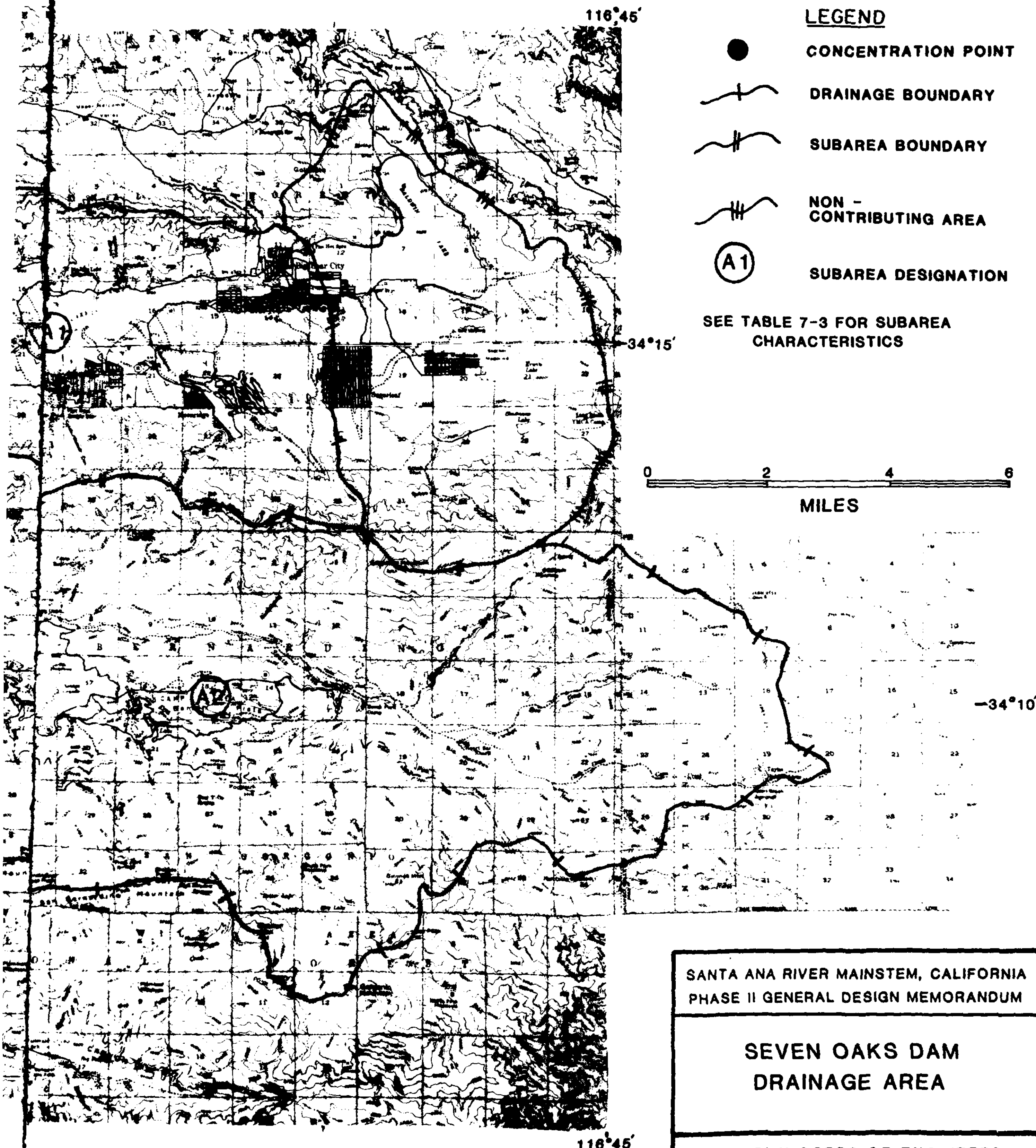
US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-1

1

2


117°00'
LOS ANGELES CO.
SAN BERNARDINO CO.
RIVERSIDE CO.
ORANGE CO.
SAN DIEGO CO.
PACIFIC OCEAN
VICINITY MAP
AREA COVERED BY MAP
SCALE IN MILES
N
34°15'
A1
34°10'
A3
DAM SITE
117°00'

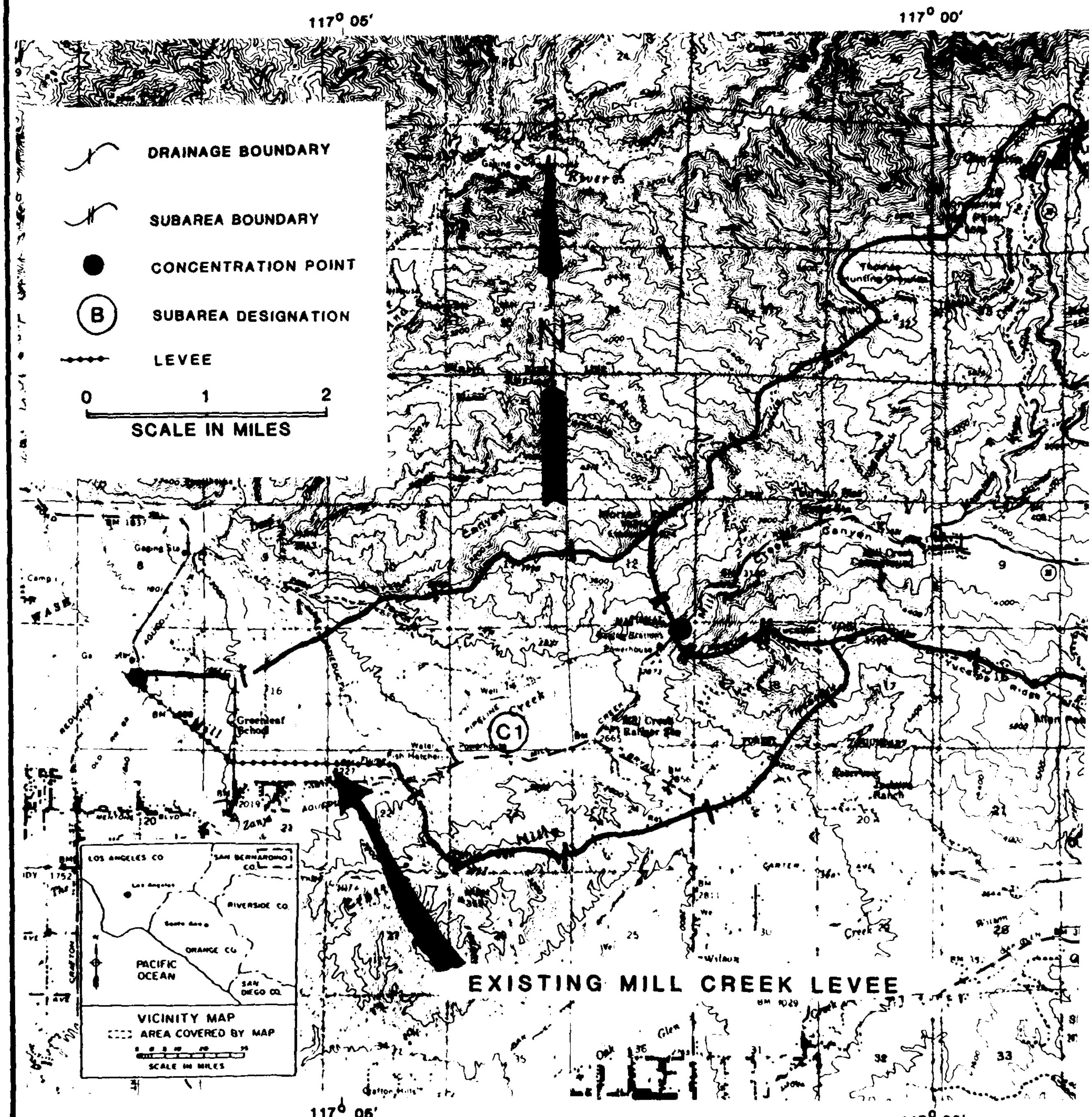


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

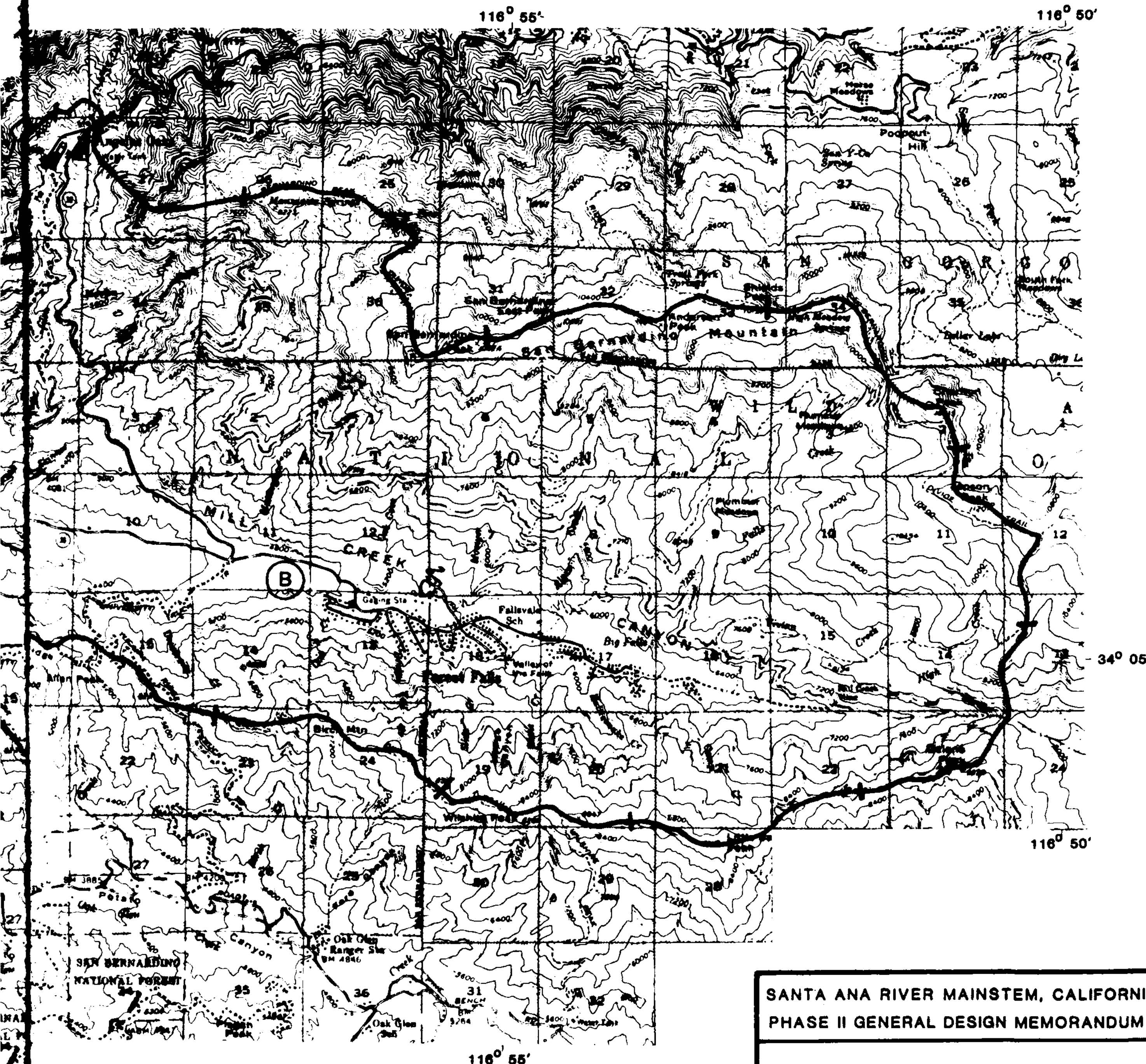
SEVEN OAKS DAM
DRAINAGE AREA

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-2



117° 05'
117° 00'
DRAINAGE BOUNDARY
SUBAREA BOUNDARY
CONCENTRATION POINT
B
SUBAREA DESIGNATION
LEVEE
0
1
2
SCALE IN MILES
C1
EXISTING MILL CREEK LEVEE
LOS ANGELES CO
SAN BERNARDINO CO
RIVERSIDE CO
ORANGE CO
PACIFIC OCEAN
SAN DIEGO CO
VICINITY MAP
AREA COVERED BY MAP
SCALE IN MILES
117° 05'
117° 00'



SEE TABLE 7-3 FOR SUBAREA CHARACTERISTICS

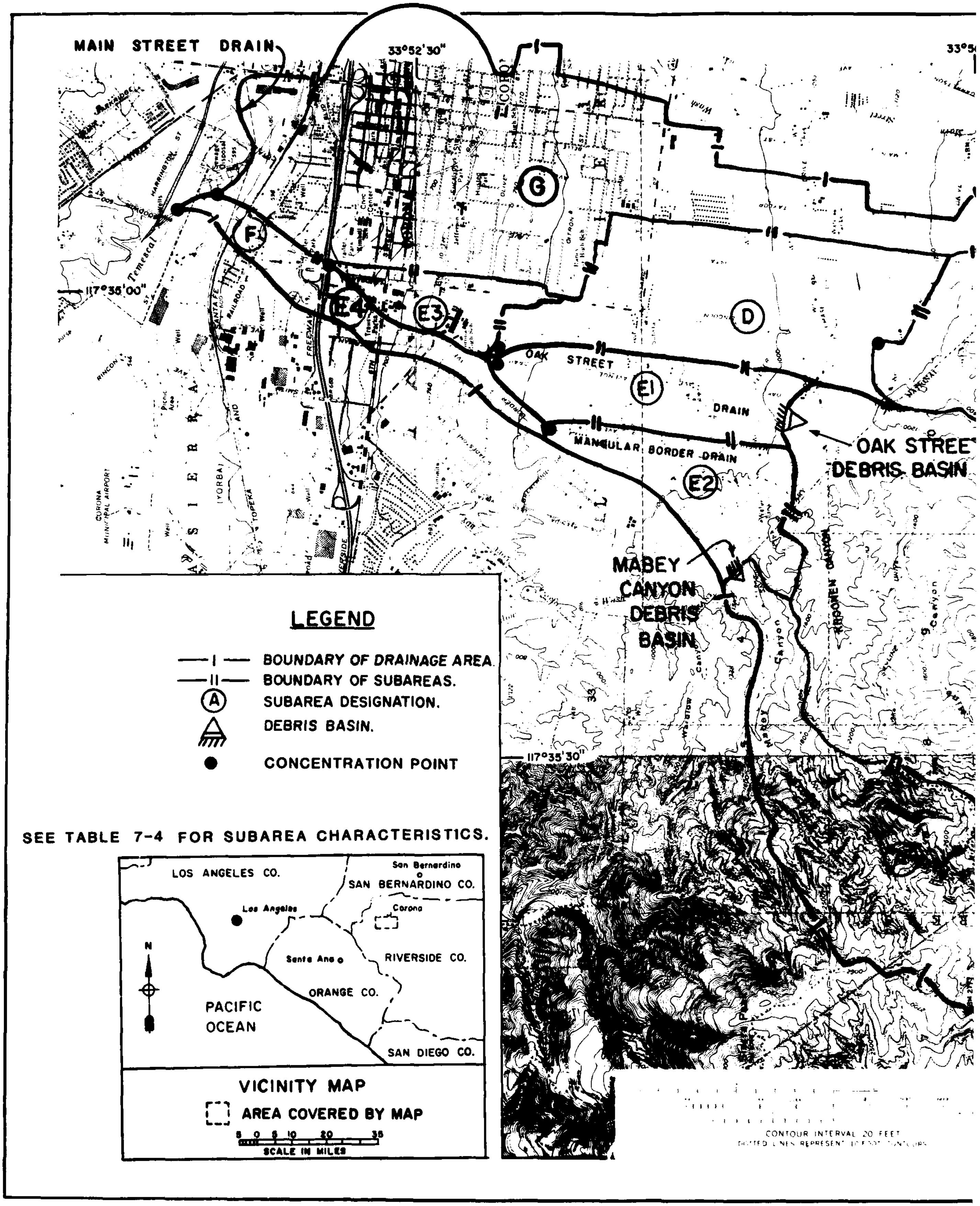
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

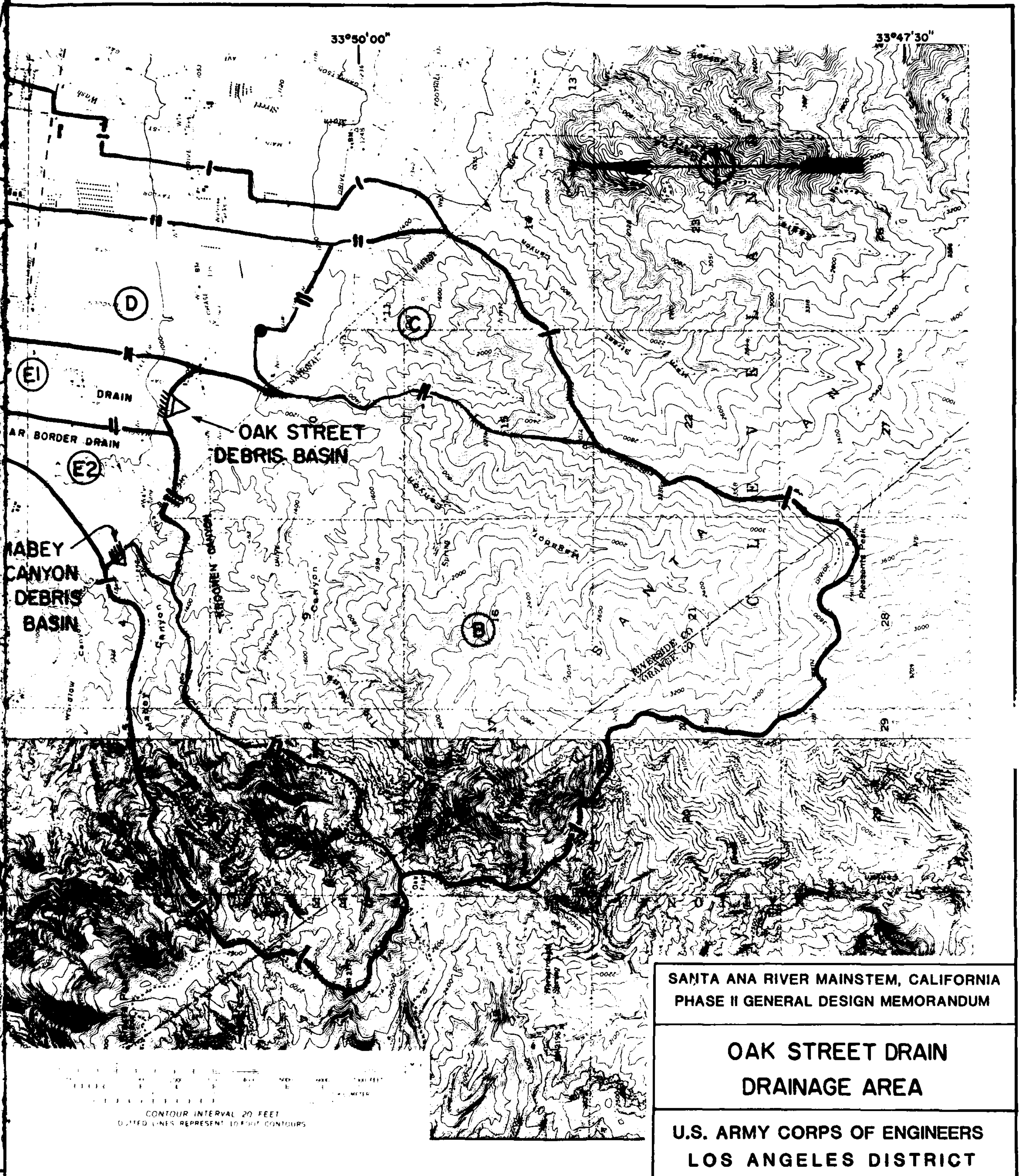
MILL CREEK
DRAINAGE AREA

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-3

2


MAIN STREET DRAIN
33°52'30"
117°35'00"
117°35'30"
G
F
E4
E3
D
E1
E2
OAK STREET DRAIN
MANGULAR BORDER DRAIN
OAK STREET DEBRIS BASIN
MABEY CANYON DEBRIS BASIN
CORONA MUNICIPAL AIRPORT
LEGEND
BOUNDARY OF DRAINAGE AREA.
BOUNDARY OF SUBAREAS.
A SUBAREA DESIGNATION.
DEBRIS BASIN.
CONCENTRATION POINT
SEE TABLE 7-4 FOR SUBAREA CHARACTERISTICS.
LOS ANGELES CO.
San Bernardino
SAN BERNARDINO CO.
Los Angeles
Corona
Santa Ana
RIVERSIDE CO.
ORANGE CO.
PACIFIC OCEAN
SAN DIEGO CO.
N
VICINITY MAP
AREA COVERED BY MAP
5 0 5 10 20 35
SCALE IN MILES
CONTOUR INTERVAL 20 FEET

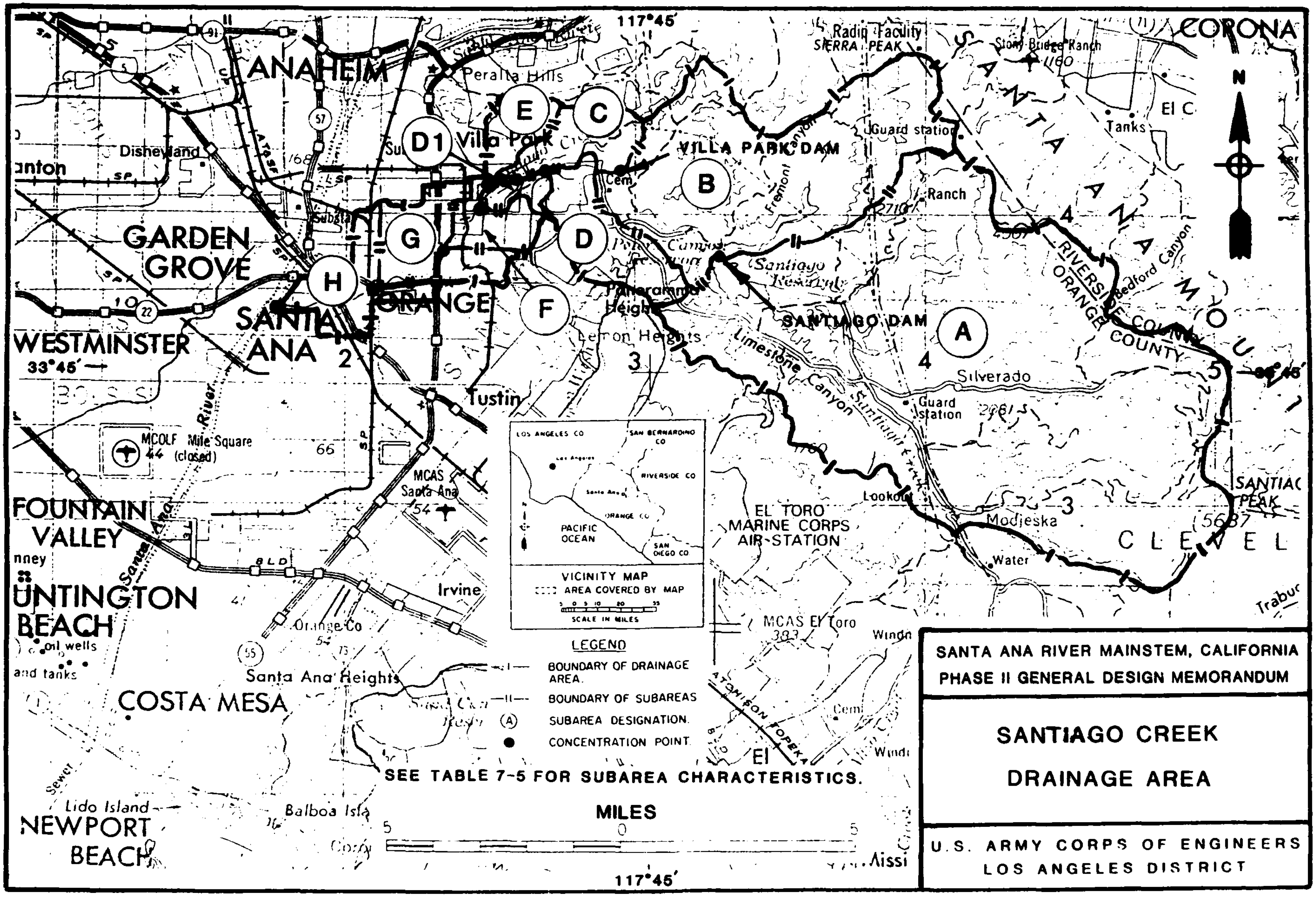


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

OAK STREET DRAIN DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-4

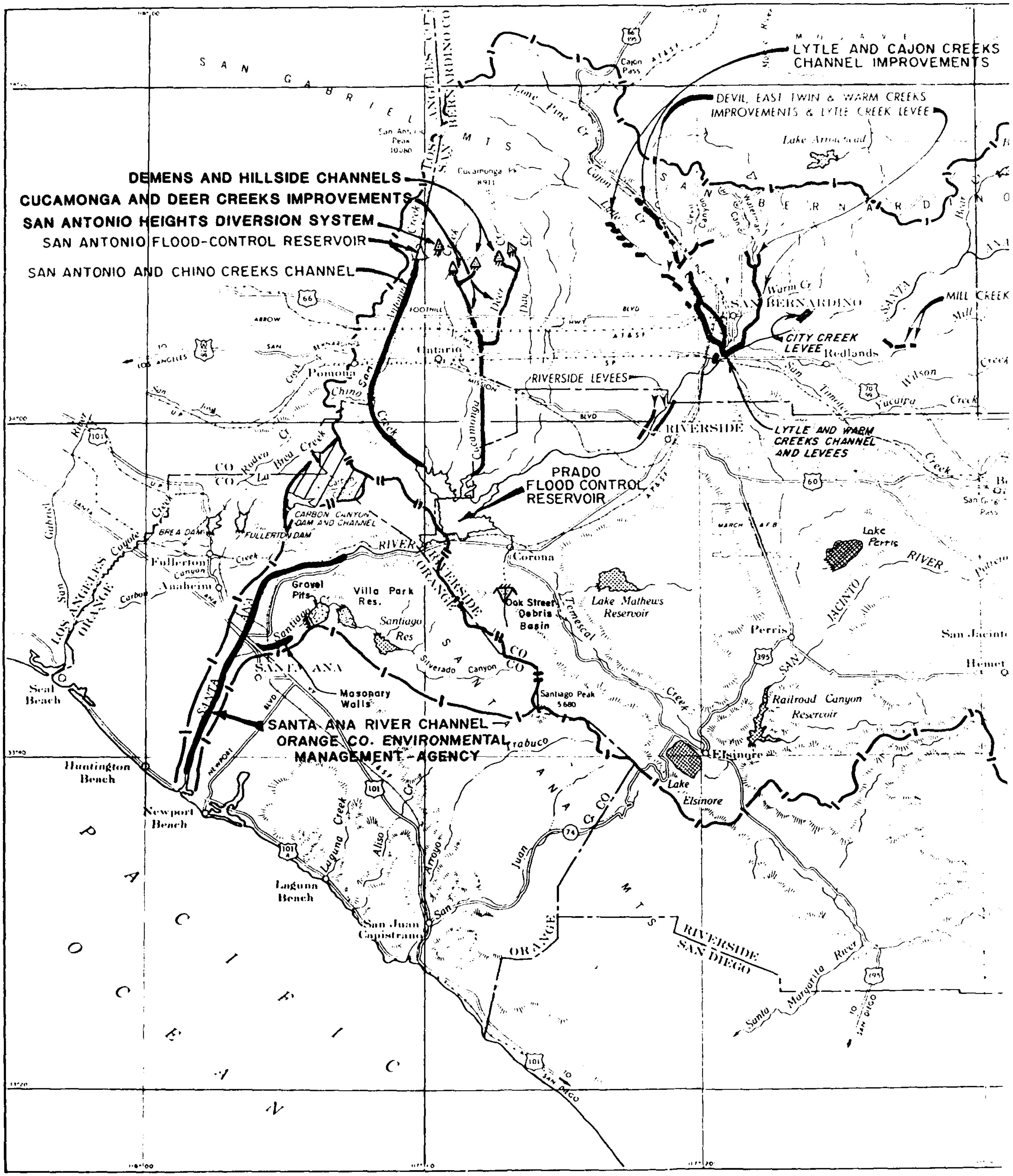


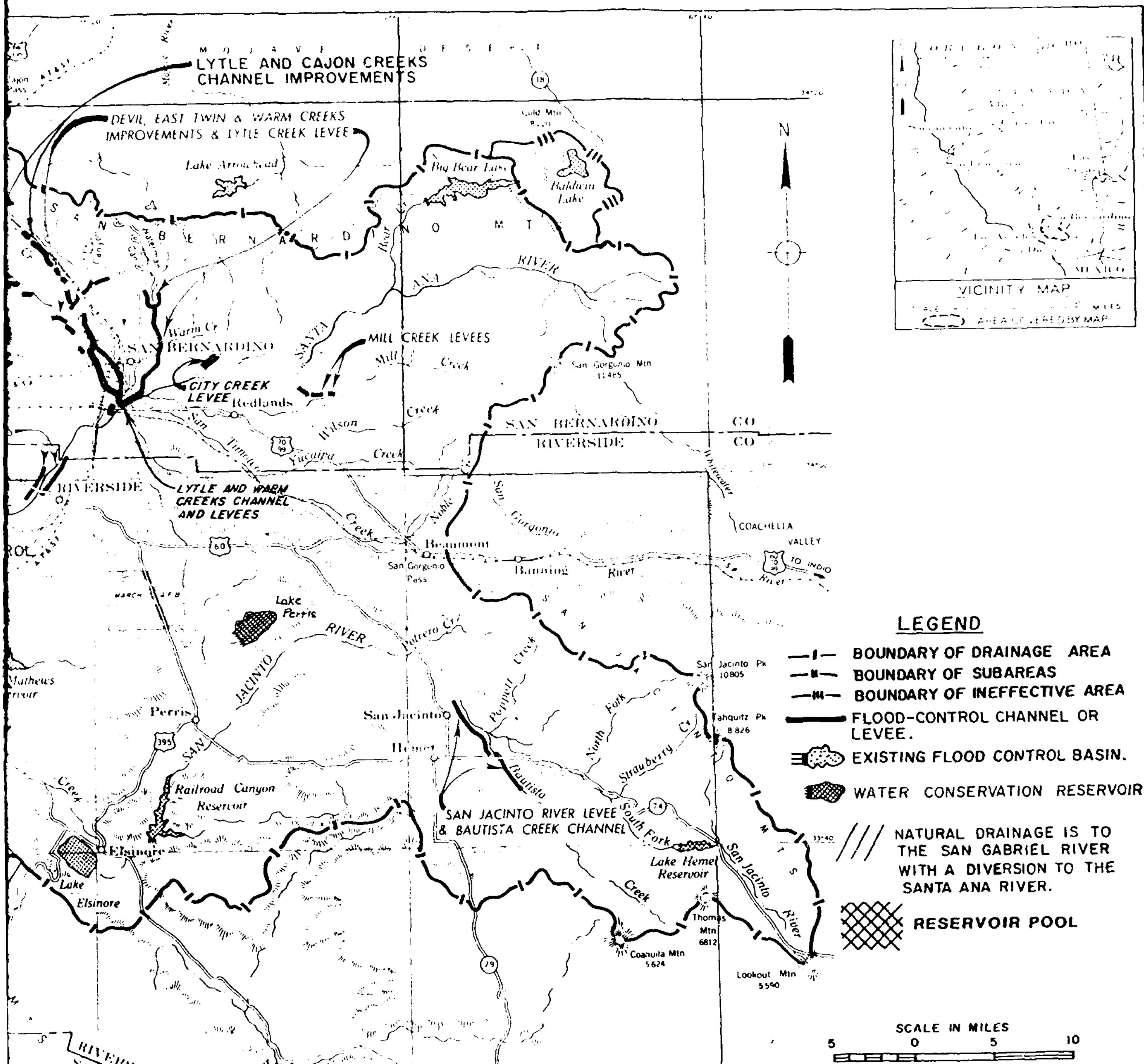
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTIAGO CREEK
DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-5


LYTLE AND CAJON CREEKS CHANNEL IMPROVEMENTS
DEVIL, EAST TWIN & WARM CREEKS IMPROVEMENTS & LYTLE CREEK LEVEE
DEMENS AND HILLSIDE CHANNELS
CUCAMONGA AND DEER CREEKS IMPROVEMENTS
SAN ANTONIO HEIGHTS DIVERSION SYSTEM
SAN ANTONIO FLOOD-CONTROL RESERVOIR
SAN ANTONIO AND CHINO CREEKS CHANNEL
MILL CREEK
CITY CREEK LEVEE
RIVERSIDE LEVEES
LYTLE AND WARM CREEKS CHANNEL AND LEVEES
PRADO FLOOD CONTROL RESERVOIR
CARBON CANYON DAM AND CHANNEL
BREA DAM
FULLERTON DAM
Oak Street Debris Basin
Masonary Walls
SANTA ANA RIVER CHANNEL
ORANGE CO. ENVIRONMENTAL MANAGEMENT AGENCY
SAN GABRIEL MTS
SAN BERNARDINO
Cajon Pass
Lake Arrowhead
Cucamonga Pk 8911
San Antonio Peak 10080
Ontario
Pomona
Redlands
RIVERSIDE
Corona
Fullerton
Anaheim
Lake Mathews Reservoir
Lake Perris
Perris
San Jacinto
Hemet
Railroad Canyon Reservoir
Elsinore
Lake Elsinore
Santiago Peak 5680
Santiago Res
Villa Park Res.
Gravel Pits
Silverado Canyon
Seal Beach
Huntington Beach
Newport Beach
Laguna Beach
San Juan Capistrano
SANTA ANA MTS
PACIFIC OCEAN
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
MARCH AFB



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

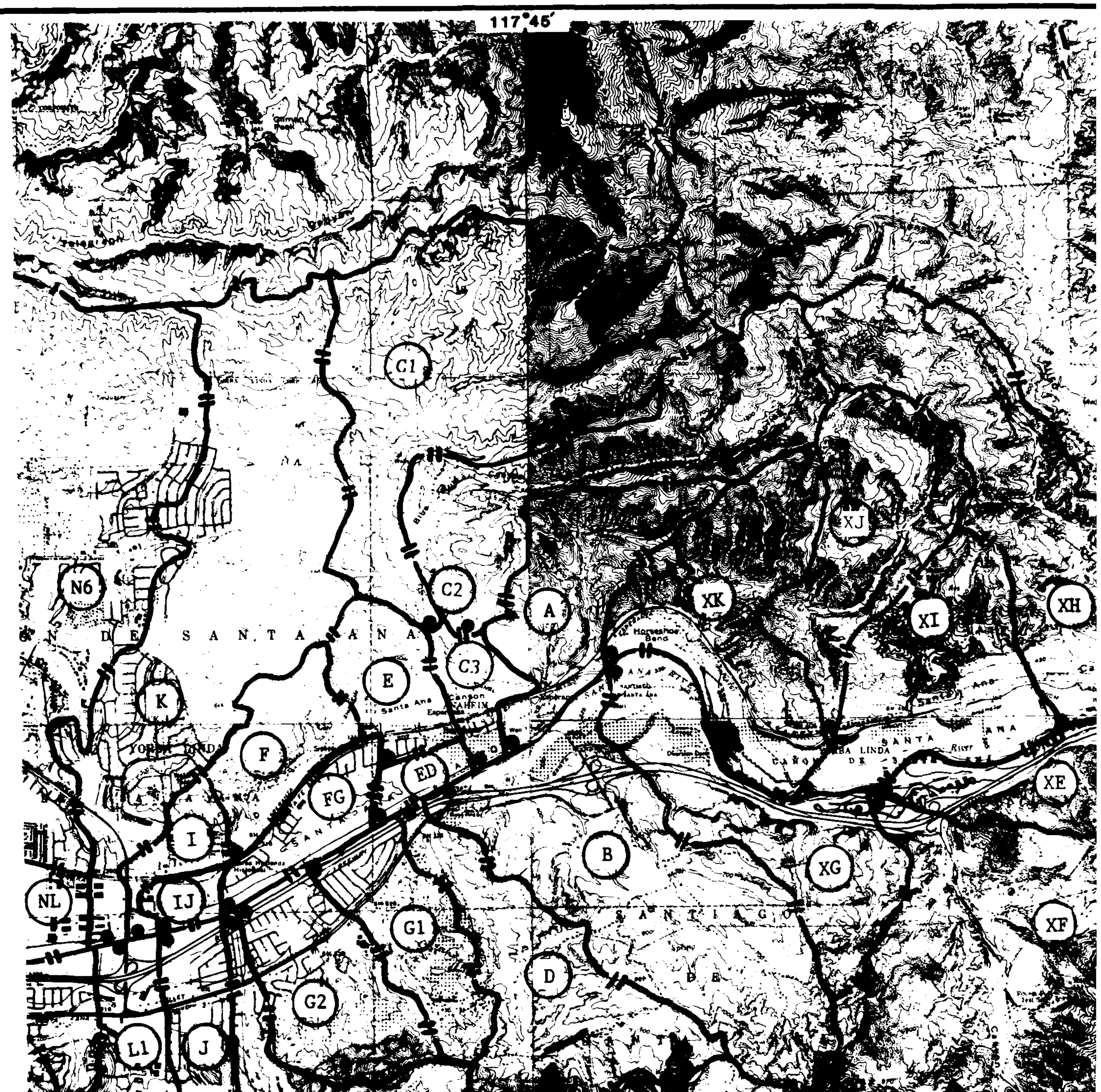
EXISTING STRUCTURES

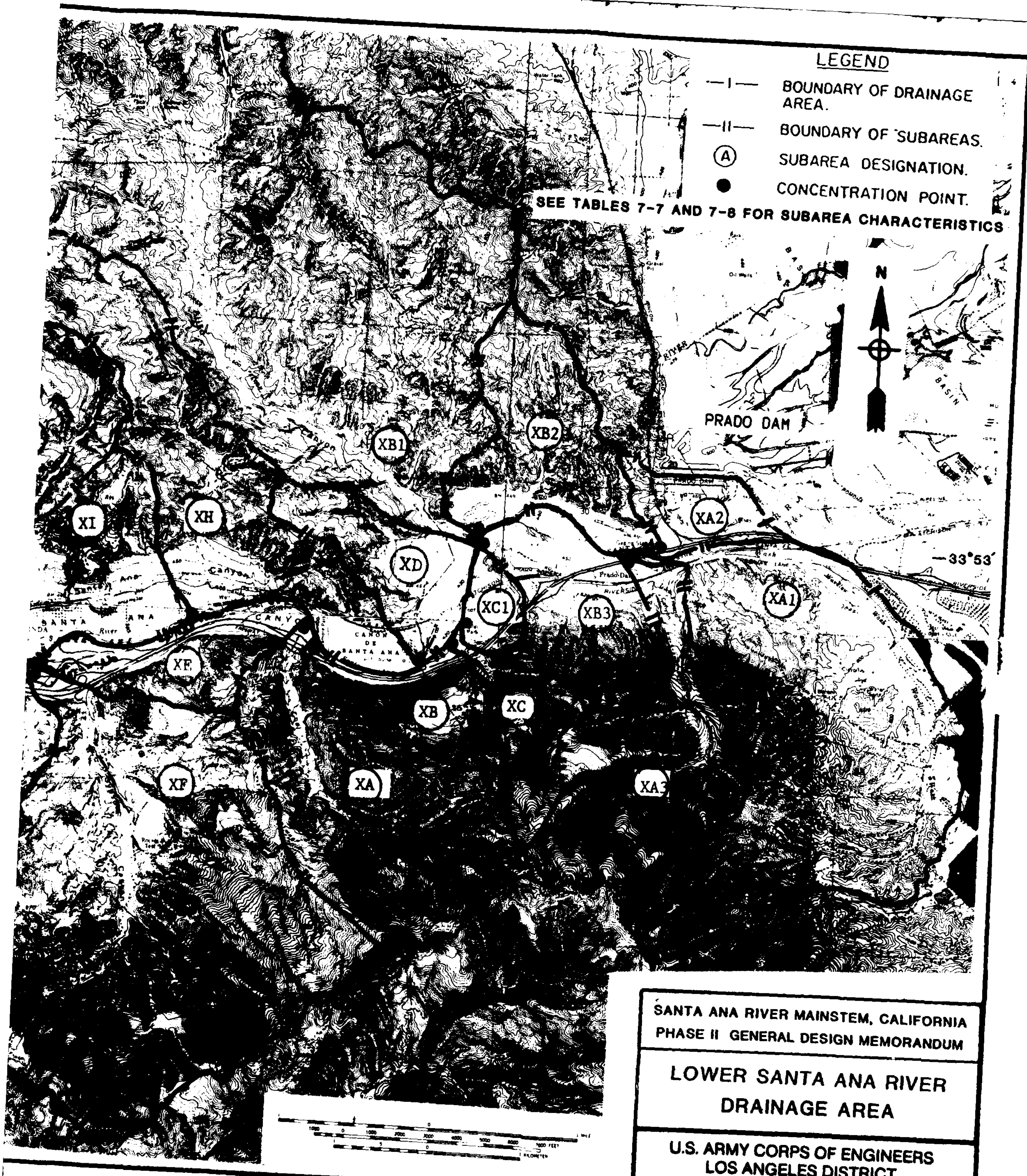
US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-6

2

MATCH TO PLATE 7-8





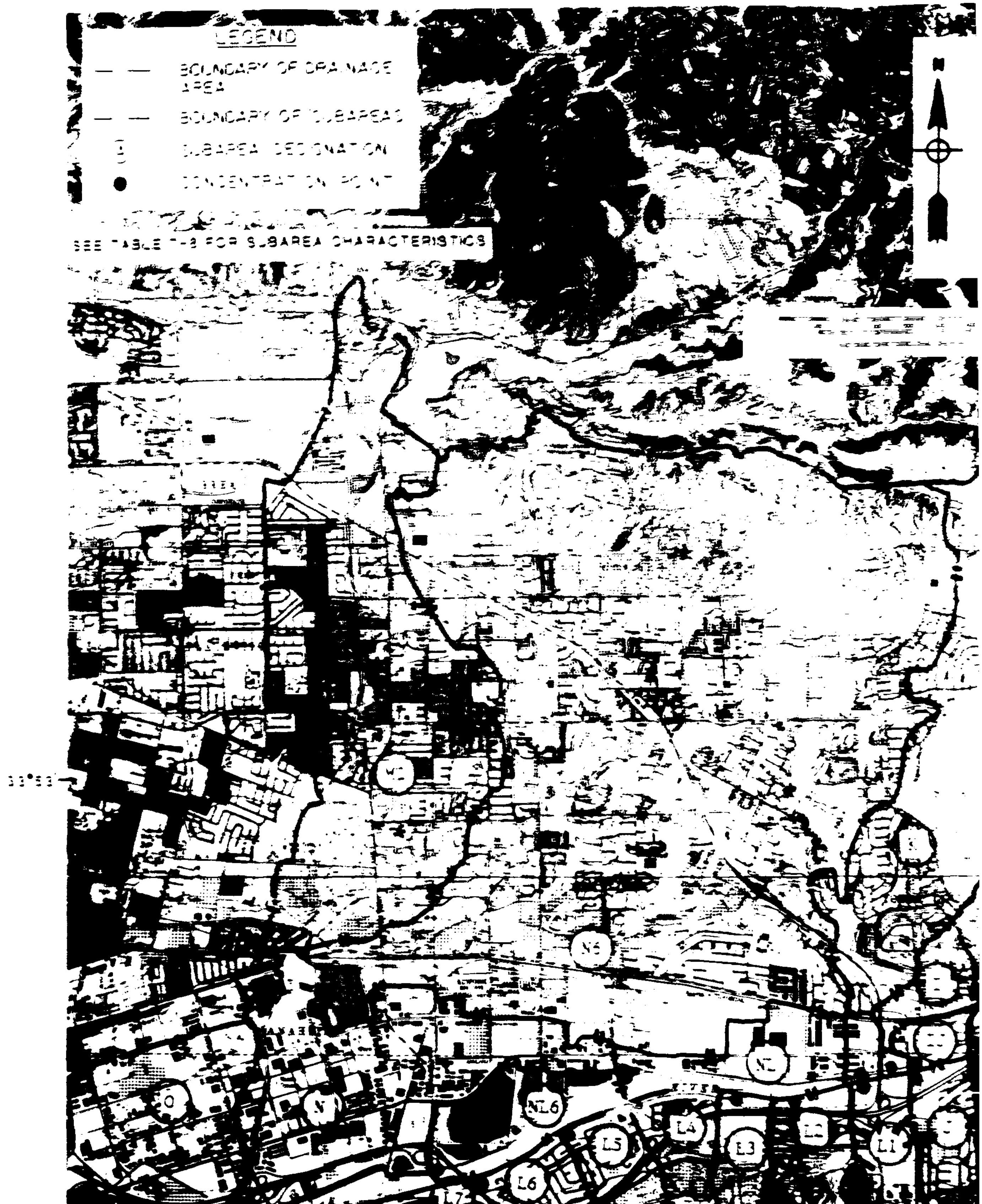
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

2

PLATE 7-7

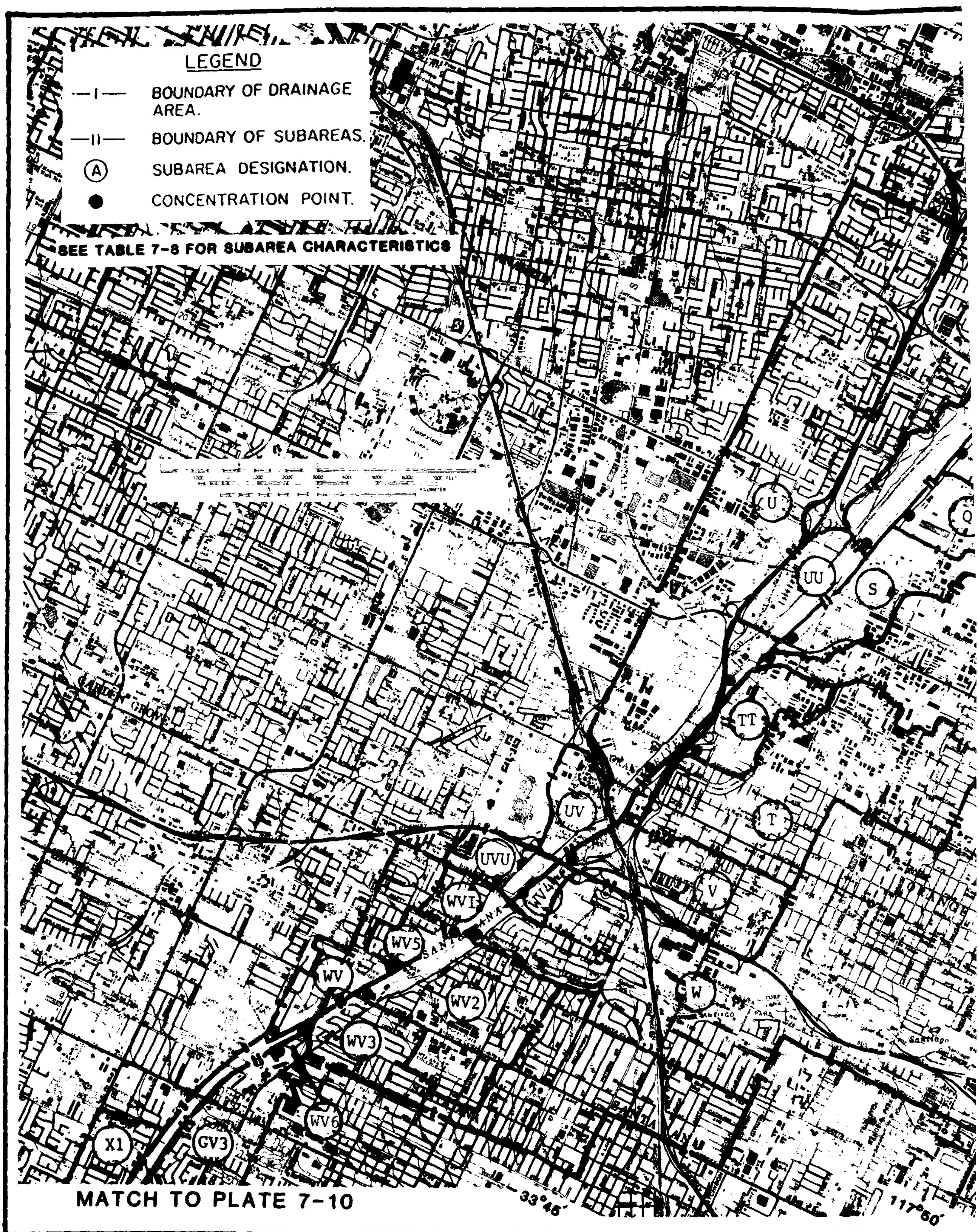


MATCH TO PLATE 7-9

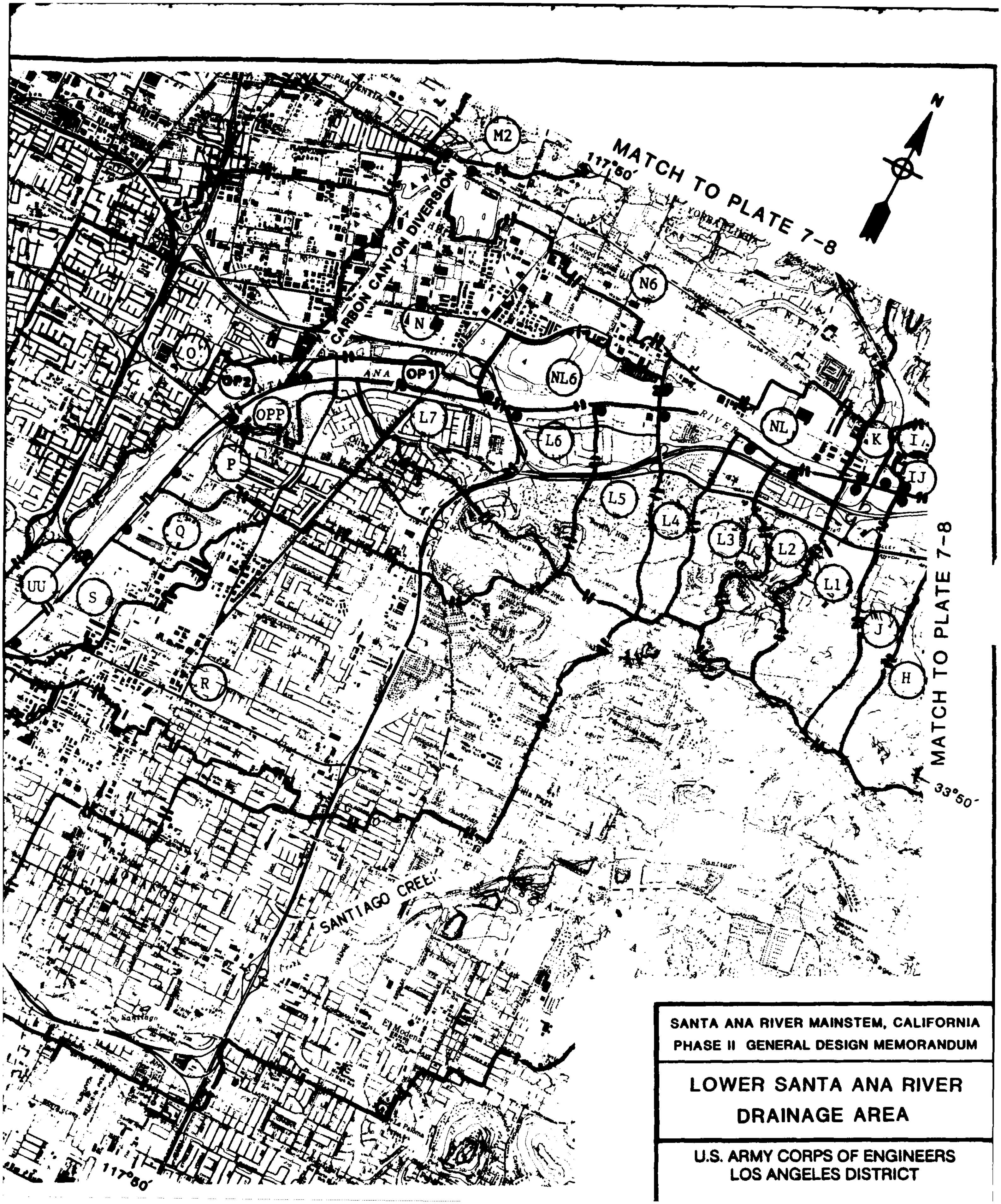

117°45′
117°45′
H TO PLATE 7-9
MATCH TO PLATE 7-7
C1
C2
C3
A
B
D
E
ED
F
FG
G1
G2
H
I
IJ
J
K
L1
L2
XB1
XE
XF
XG
XH
XI
XJ
XK
SANTA ANA
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER
DRAINAGE AREA
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-8

/ 2



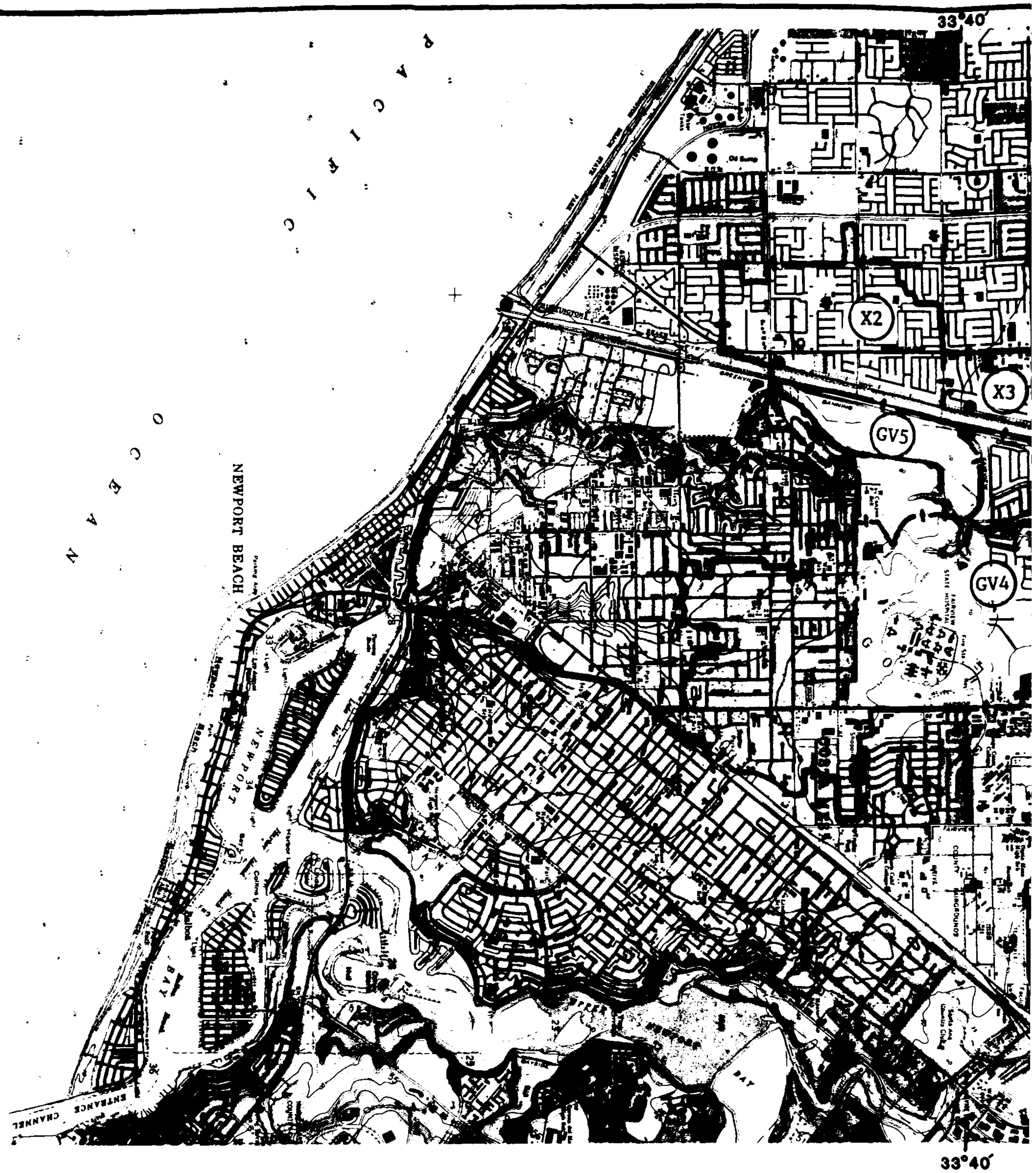
LEGEND
—I— BOUNDARY OF DRAINAGE AREA.
—II— BOUNDARY OF SUBAREAS.
(A) SUBAREA DESIGNATION.
● CONCENTRATION POINT.
SEE TABLE 7-8 FOR SUBAREA CHARACTERISTICS
U
Q
UU
S
TT
UV
T
UVU
WV1
WV4
V
WV5
WV
WV2
W
WV3
WV6
X1
GV3
SANTA ANA RIVER
GARDEN GROVE
MATCH TO PLATE 7-10
33°45'
117°50'

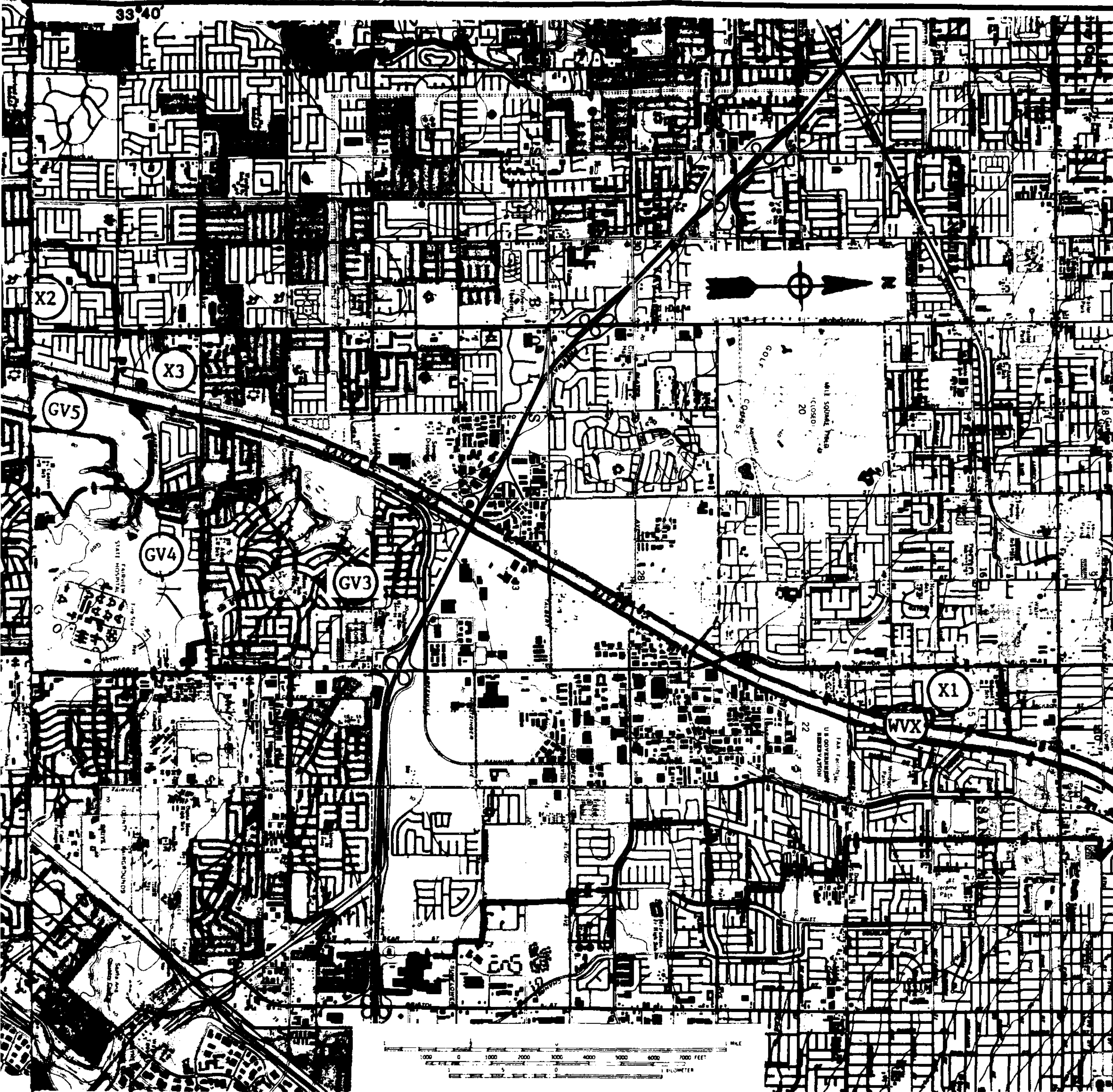


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER
DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


33°40′
P A C I F I C
O C E A N
NEWPORT BEACH
X2
X3
GV5
GV4
NEWPORT
ENTRANCE CHANNEL
BAY
33°40′



SEE TABLE 7-8 FOR SUBAREA CHARACTERISTICS

LEGEND

—I— BOUNDARY OF DRAINAGE AREA.

—II— BOUNDARY OF SUBAREAS.

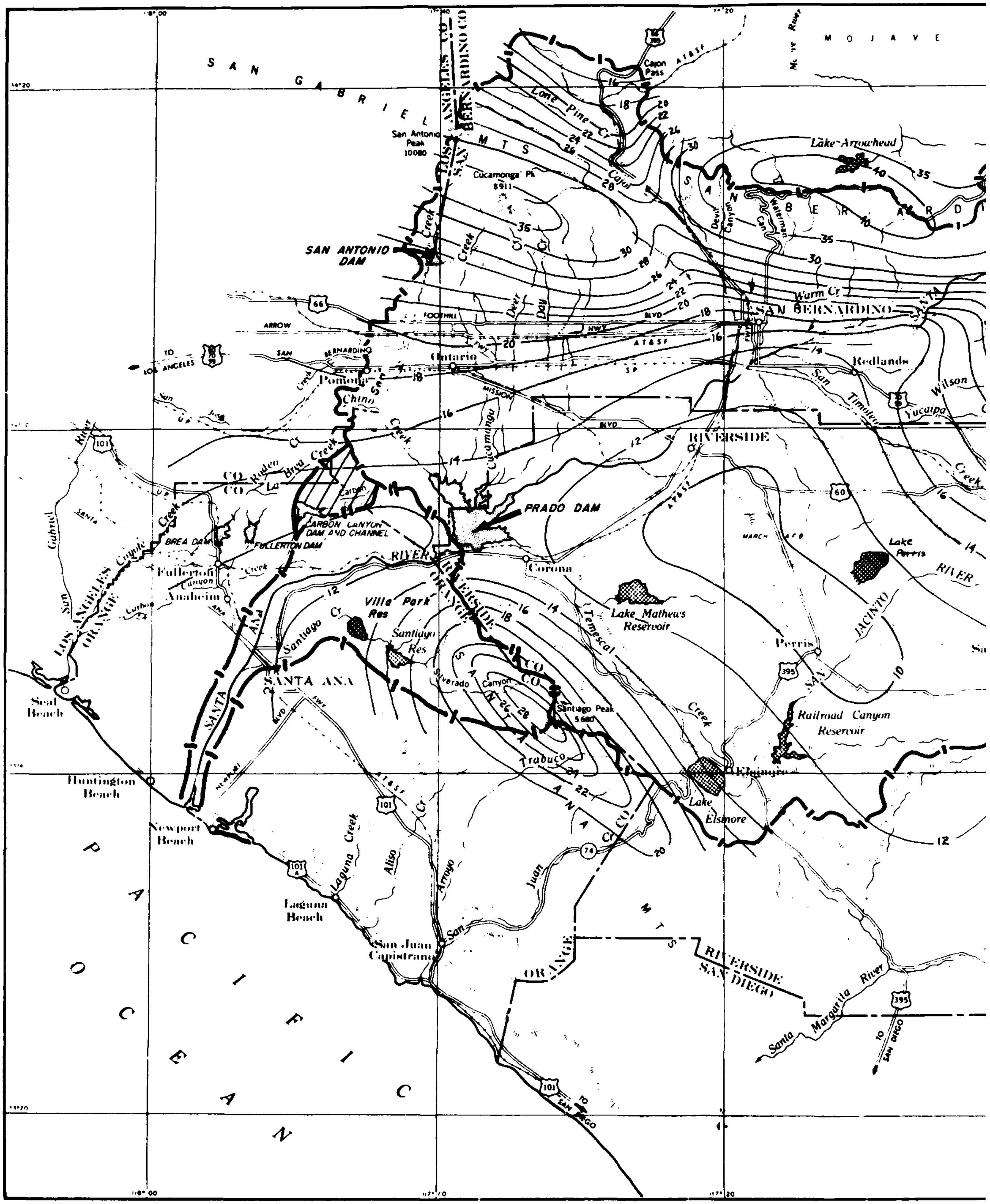
Ⓐ SUBAREA DESIGNATION.

● CONCENTRATION POINT.

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER
DRAINAGE AREA

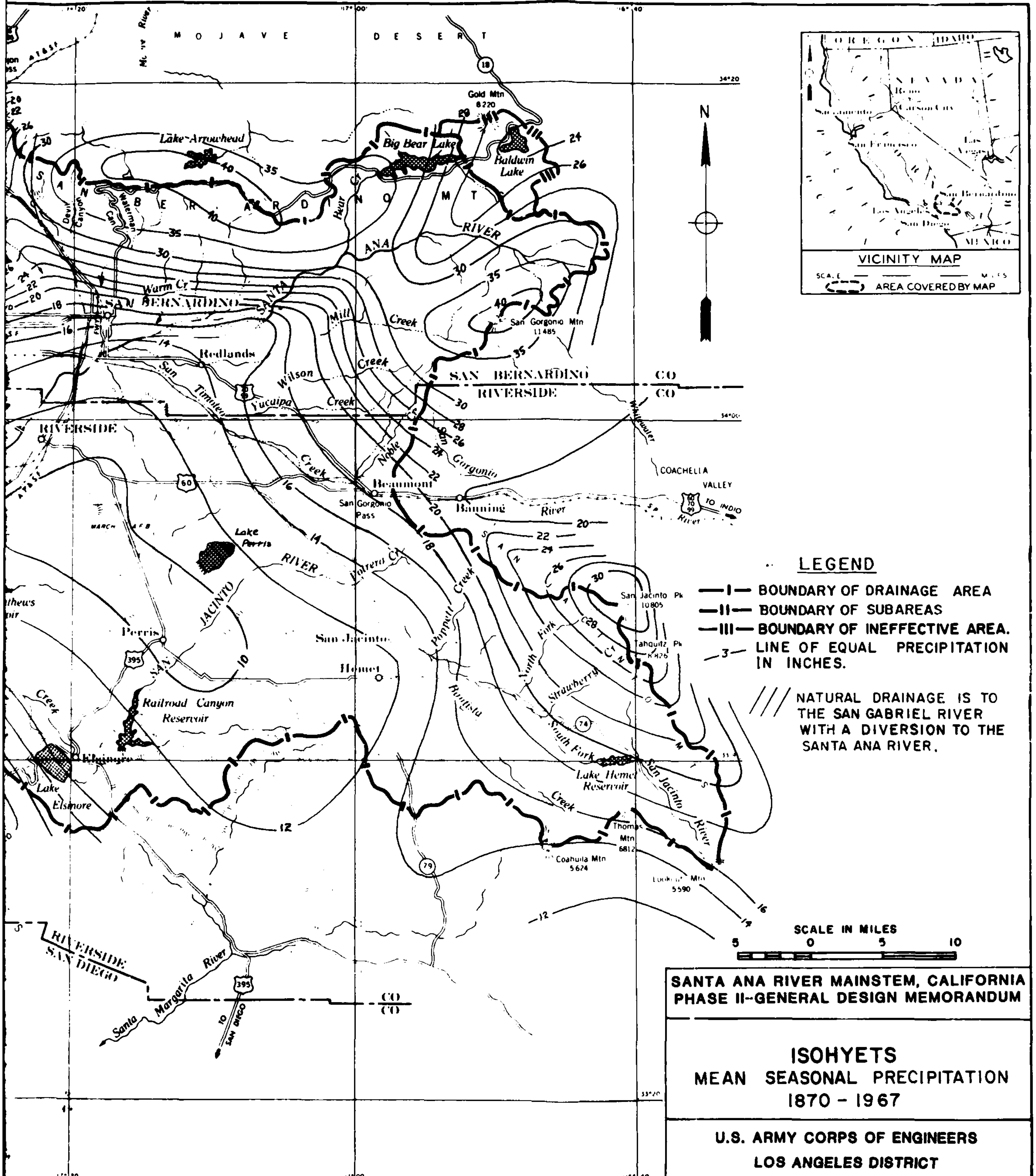
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



MOJAVE
SAN GABRIEL MTS
LOS ANGELES CO
SAN BERNARDINO CO
Cajon Pass
Lone Pine Cr
Cajon
Lake Arrowhead
San Antonio Peak 10080
Cucamonga Pk 8911
SAN BERNARDINO
SAN ANTONIO DAM
Devil Canyon
Waterman Can
Warm Cr
SAN BERNARDINO
Deer
Day
FOOTHILL BLVD
ARROW
SAN BERNARDINO FWY
TO LOS ANGELES
Ontario
Pomona
Chino
Redlands
San Timoteo
Yucaipa
Wilson
MISSION BLVD
RIVERSIDE
Cucamonga
Rodeo
La Brea Creek
Carbon
CARBON CANYON DAM AND CHANNEL
PRADO DAM
BREA DAM
FULLERTON DAM
Fullerton
Anaheim
Corona
RIVER
MARCH AFB
Lake Perris
RIVER
SAN JACINTO
Lake Mathews Reservoir
Temescal
Perris
Villa Park Res
Santiago Cr
Santiago Res
SANTA ANA
Silverado Canyon
Santiago Peak 5680
Trabuco
SANTA ANA MTS
Creek
Railroad Canyon Reservoir
Elsinore
Lake Elsinore
Seal Beach
Huntington Beach
Newport Beach
Laguna Beach
Laguna Creek
Aliso
Arroyo
San Juan Capistrano
San Juan Cr
ORANGE
RIVERSIDE
SAN DIEGO
Santa Margarita River
TO SAN DIEGO
LOS ANGELES
ORANGE
San Gabriel
Coyote Creek
SANTA ANA
PACIFIC OCEAN

1

1



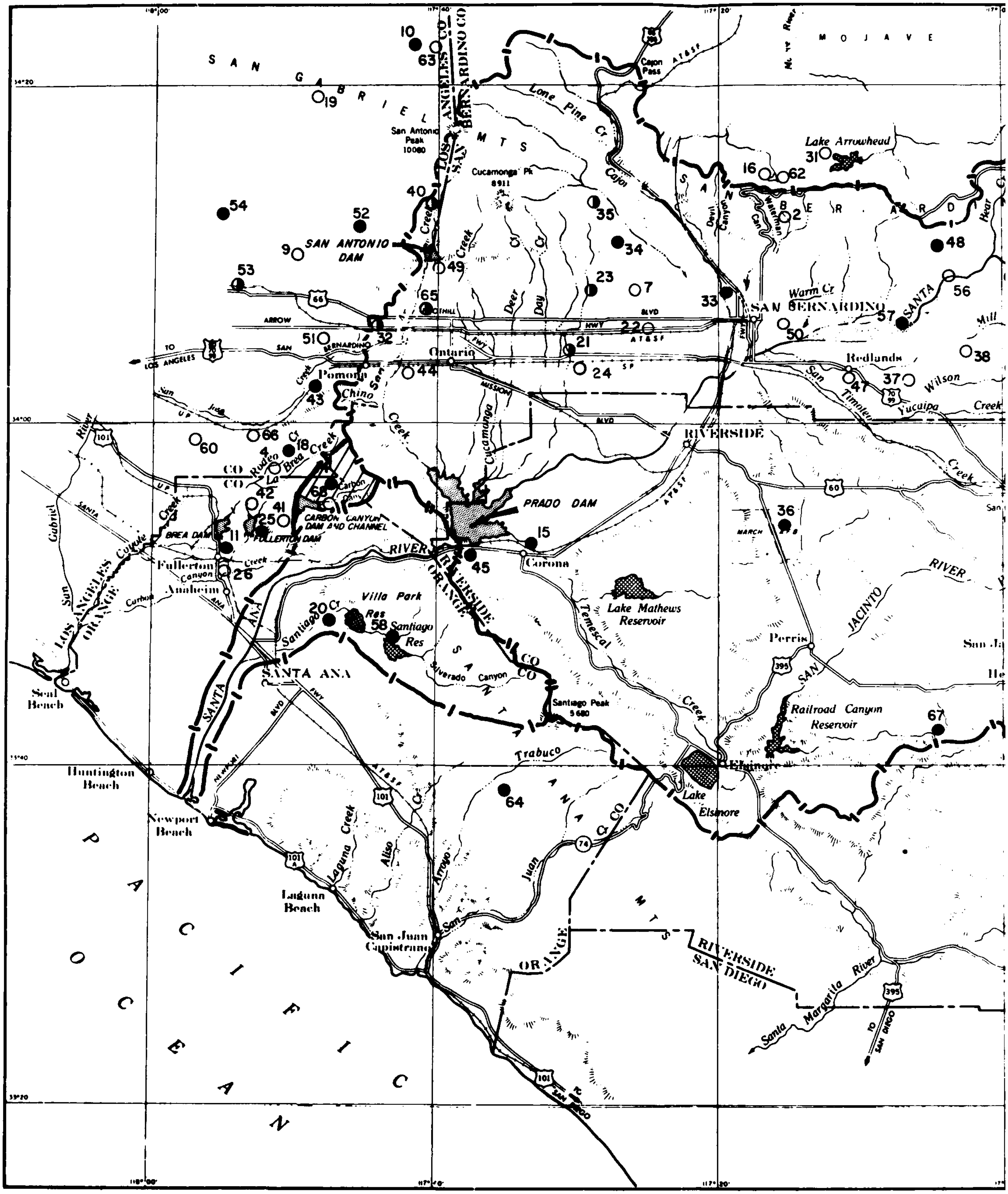
LEGEND

- BOUNDARY OF DRAINAGE AREA
- BOUNDARY OF SUBAREAS
- BOUNDARY OF INEFFECTIVE AREA.
- 3 — LINE OF EQUAL PRECIPITATION IN INCHES.
- NATURAL DRAINAGE IS TO THE SAN GABRIEL RIVER WITH A DIVERSION TO THE SANTA ANA RIVER.

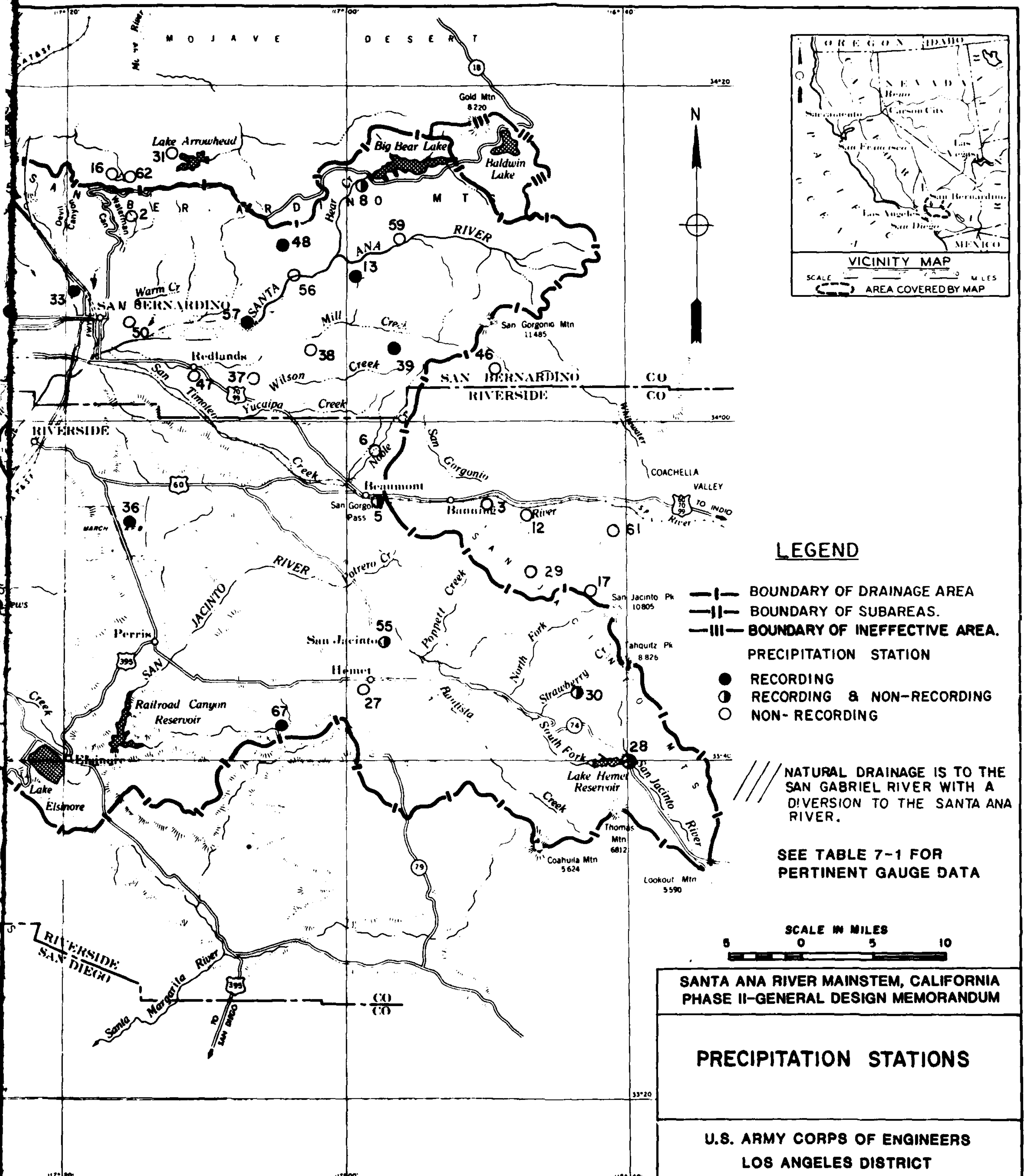
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II-GENERAL DESIGN MEMORANDUM

ISOHYETS
MEAN SEASONAL PRECIPITATION 1870 - 1967

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



MOJAVE
SAN GABRIEL MTS
San Antonio Peak 10080
Cucamonga Pk 8911
LOS ANGELES CO
SAN BERNARDINO CO
Cajon Pass
Lone Pine Cr
Cajon
Lake Arrowhead
SAN BERNARDINO
SAN ANTONIO DAM
Deer
Day
Warm Cr
SANTA
Mill
ARROW
FOOTHILL
BLVD
HWY
FWY
AT&SF
SP
TO LOS ANGELES
SAN BERNARDINO
Ontario
Pomona
Chino
Redlands
San Timoteo
Wilson
Yucaipa
Creek
MISSION
BLVD
Cucamonga
RIVERSIDE
San Jose
River
Rodeo Cr
Brea Creek
La
Carbon
CARBON CANYON DAM AND CHANNEL
FULLERTON DAM
BREA DAM
PRADO DAM
Coyote Creek
Gabriel
San
Fullerton
Canyon
Anaheim
Carbon
ANA
RIVER
RIVERSIDE
ORANGE
Corona
MARCH AFB
Lake Mathews Reservoir
Temescal
Creek
Perris
SAN JACINTO RIVER
Villa Park Res
Santiago Res
Santiago Cr
SANTA ANA
SANTA ANA MTS
Silverado Canyon
CO
Santiago Peak 5680
Railroad Canyon Reservoir
Elsinore
Lake Elsinore
Trabuco
Seal Beach
Huntington Beach
Newport Beach
NEWPORT BLVD
Laguna Creek
Aliso
Arroyo
Laguna Beach
San Juan Capistrano
San Juan Cr
ORANGE
RIVERSIDE
SAN DIEGO
Santa Margarita River
TO SAN DIEGO
PACIFIC OCEAN
10 63 19 40 54 52 9 53 49 35 34 23 7 65 33 57 48 56 16 62 31 2 51 32 44 21 24 22 50 38 47 37 43 60 66 4 18 42 41 25 59 11 26 15 45 36 20 58 67 64
118°00'
117°40'
117°20'
34°20'
34°00'
33°40'
33°20'



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II-GENERAL DESIGN MEMORANDUM

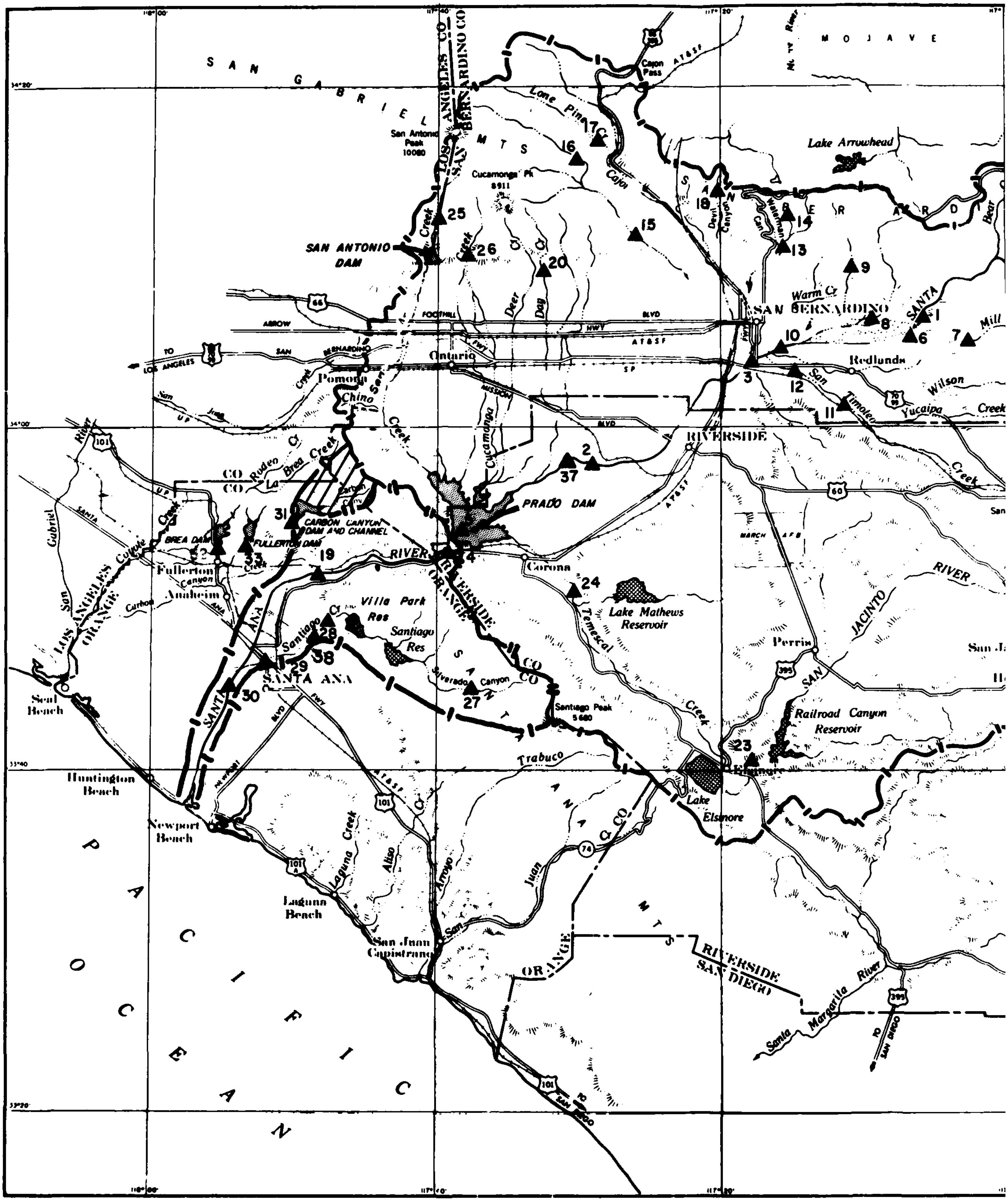
PRECIPITATION STATIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

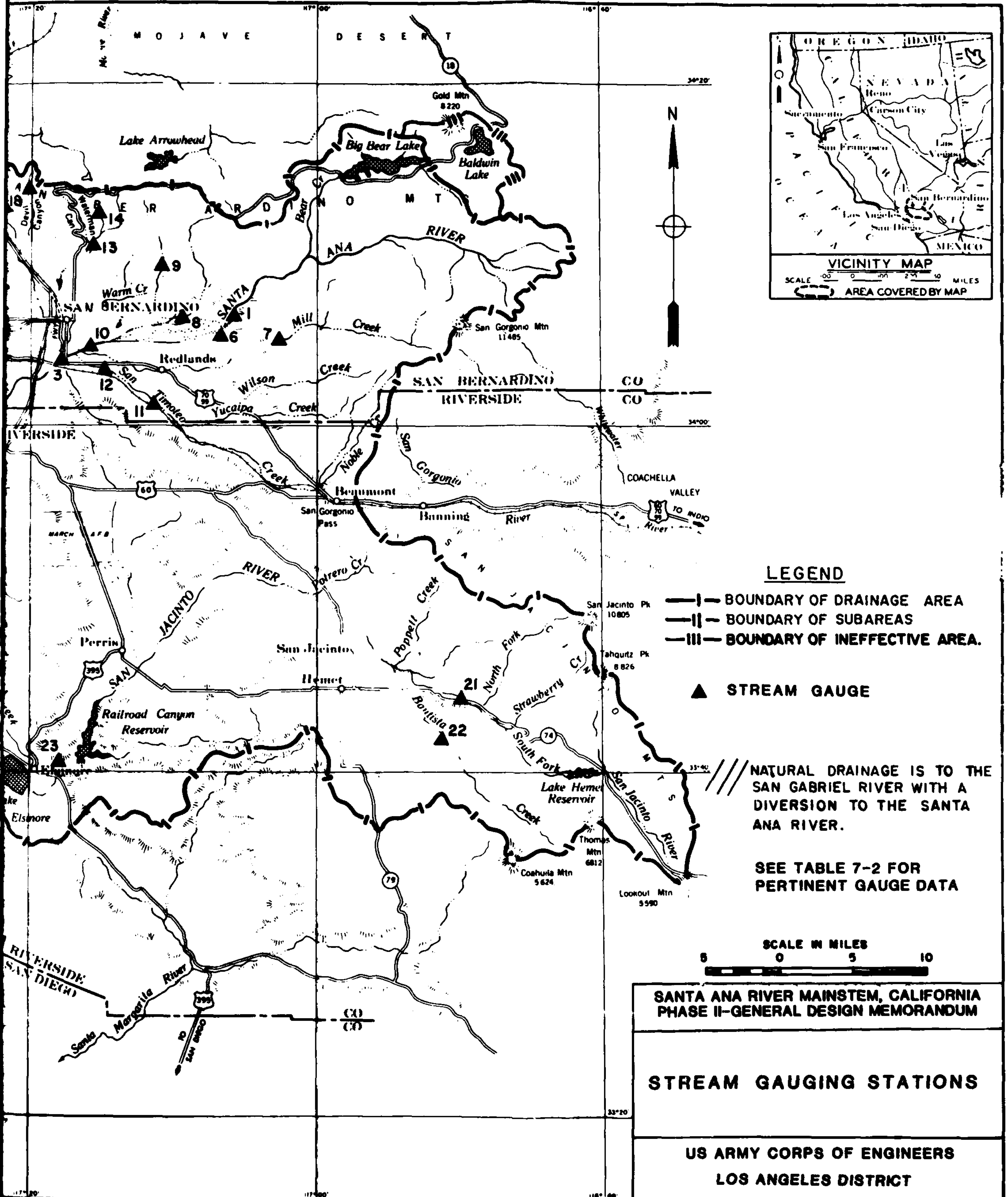
PLATE 7-12

1

2



MOJAVE
SAN GABRIEL MTS
LOS ANGELES CO
SAN BERNARDINO CO
San Antonio Peak 10080
Cucamonga Pk 8911
Lone Pine Cr
Cajon Pass
Cajon
Lake Arrowhead
SAN BERNARDINO
Devil Canyon
Warm Cr
SAN ANTONIO DAM
Deer Cr
Day Cr
FOOTHILL BLVD
ARROW HWY
AT&SF
TO LOS ANGELES
Ontario
Pomona
Chino
Redlands
San Timoteo
Wilson
Yucaipa
Creek
MISSION BLVD
Cucamonga
RIVERSIDE
PRADO DAM
Brea Creek
CARBON CANYON DAM AND CHANNEL
BREA DAM
FULLERTON DAM
Fullerton
Anaheim
Corona
SANTA ANA RIVER
Lake Mathews Reservoir
Temescal
MARCH AFB
Perris
SAN JACINTO RIVER
Villa Park Res
Santiago Res
Santiago Cr
SANTA ANA
Silverado Canyon
Santiago Peak 5680
SANTA ANA MTS
Railroad Canyon Reservoir
Elsinore
Lake Elsinore
Trabuco
Seal Beach
Huntington Beach
Newport Beach
Laguna Beach
Laguna Creek
Aliso Cr
Arroyo
San Juan Capistrano
San Juan
ORANGE
RIVERSIDE
SAN DIEGO
Santa Margarita River
TO SAN DIEGO
PACIFIC OCEAN

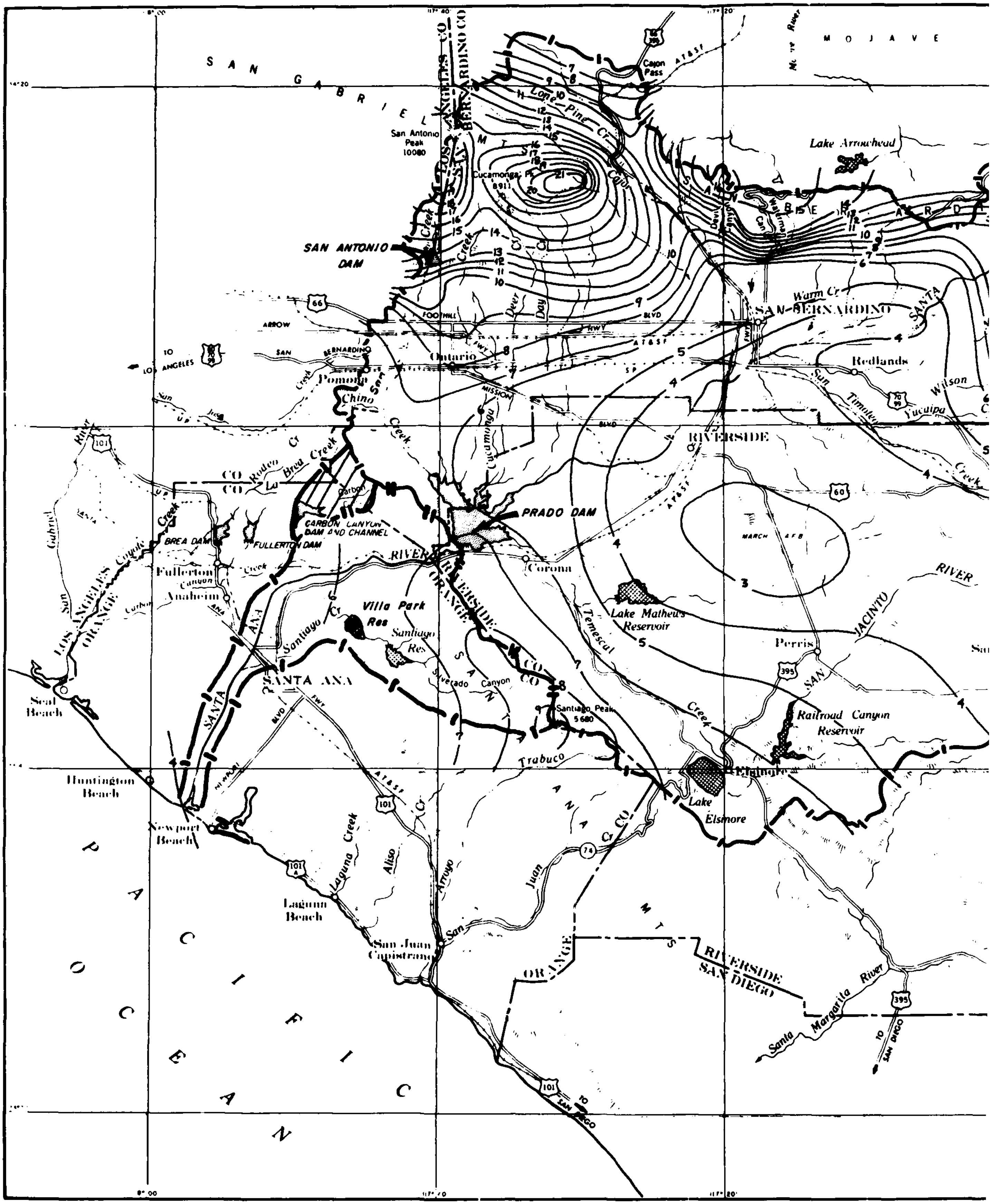


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II-GENERAL DESIGN MEMORANDUM

STREAM GAUGING STATIONS

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-13



SAN GABRIEL MTS
SAN BERNARDINO MTS
MOJAVE
PACIFIC OCEAN
SANTA ANA MTS
SAN ANTONIO DAM
PRADO DAM
BREA DAM
FULLERTON DAM
CARBON CANYON DAM AND CHANNEL
Villa Park Res
Santiago Res
Lake Mathews Reservoir
Railroad Canyon Reservoir
Lake Elsinore
Lake Arrowhead
San Antonio Peak 10080
Cucamonga Pk
Santiago Peak 5680
Cajon Pass
SAN BERNARDINO
RIVERSIDE
SANTA ANA
Ontario
Pomona
Chino
Redlands
Corona
Perris
Elsinore
Fullerton
Anaheim
Seal Beach
Huntington Beach
Newport Beach
Laguna Beach
San Juan Capistrano
MARCH AFB
LOS ANGELES CO
SAN BERNARDINO CO
ORANGE CO
RIVERSIDE CO
SAN DIEGO
TO LOS ANGELES
TO SAN DIEGO

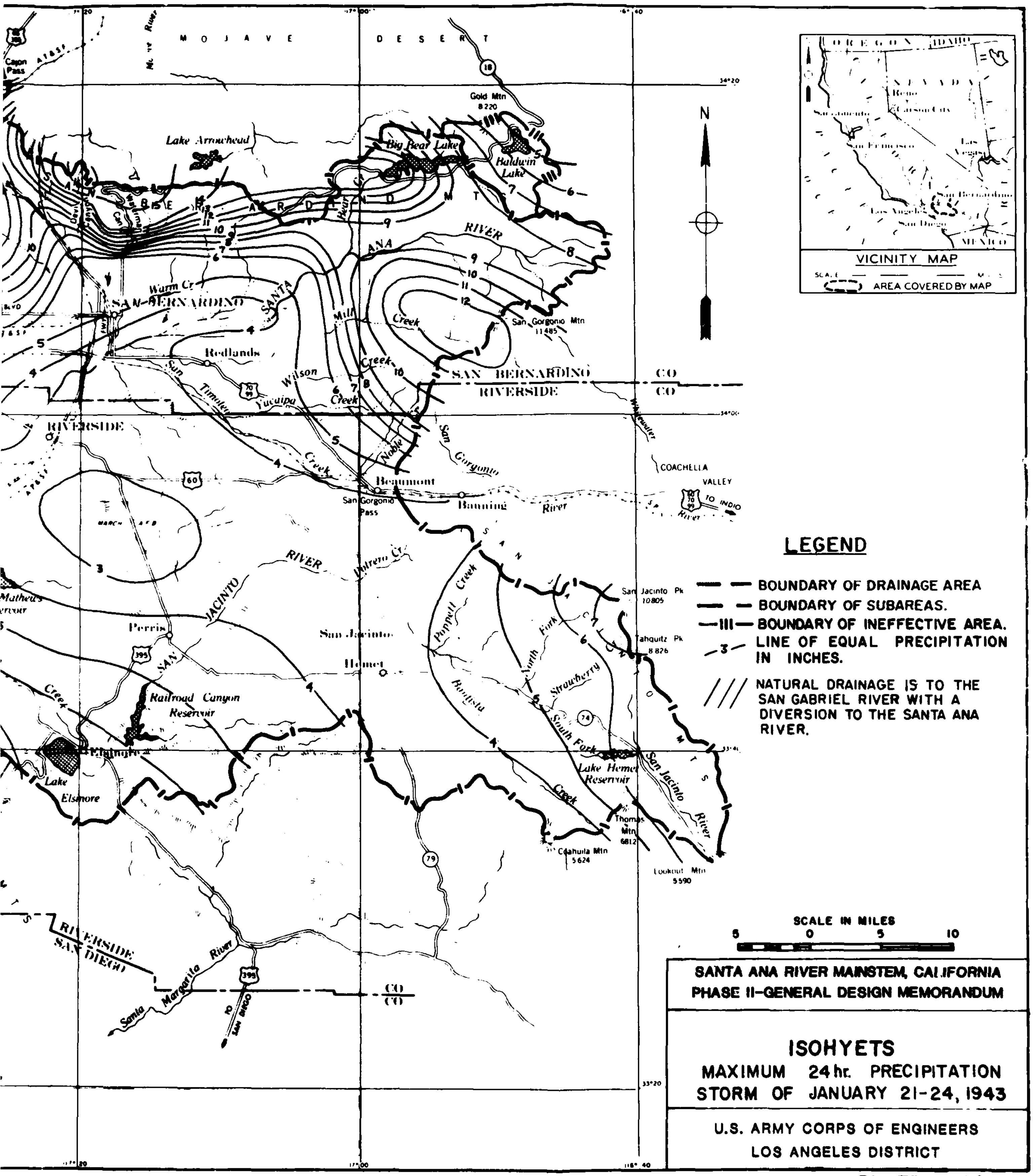
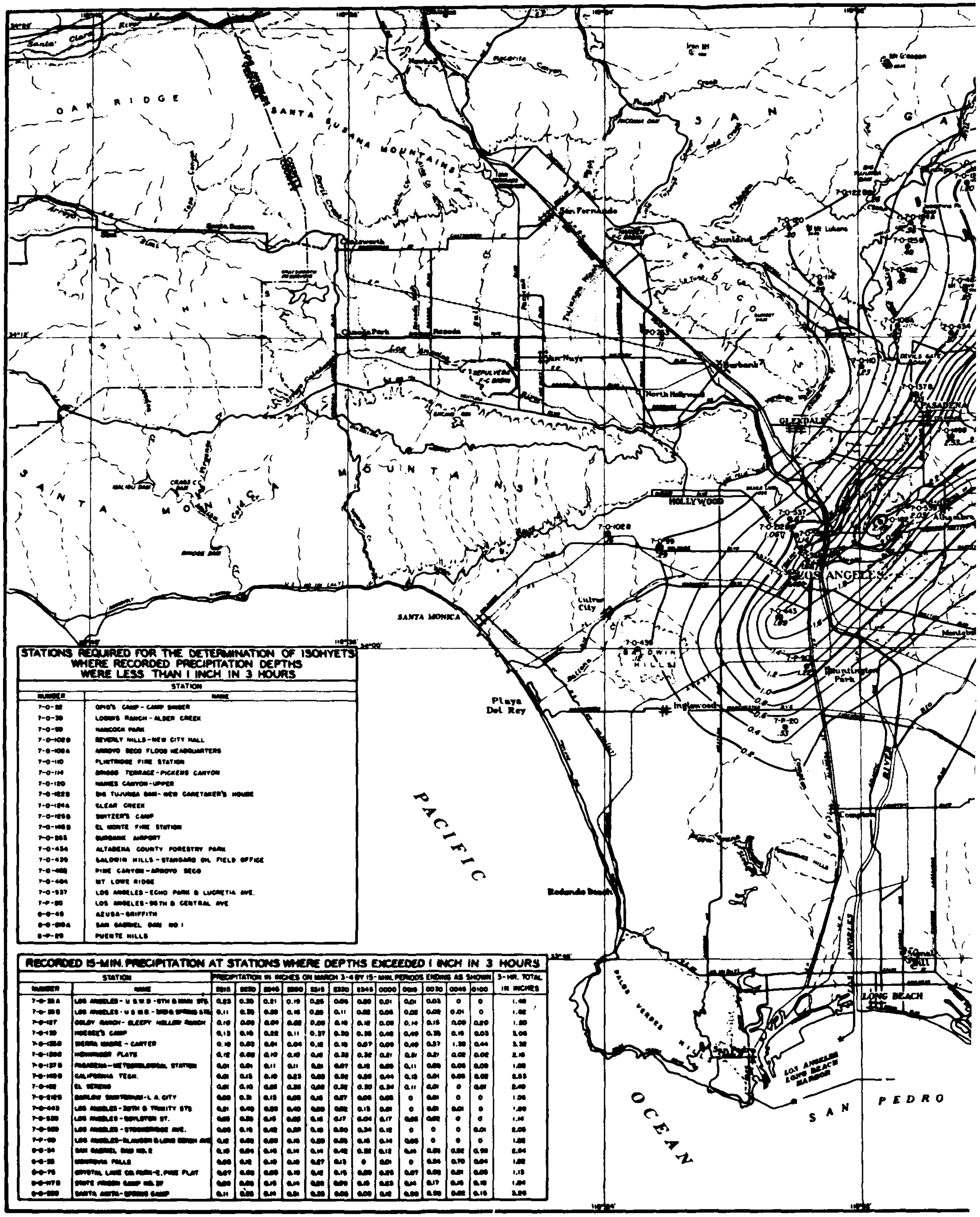

MOJAVE DESERT
Lake Arrowhead
Big Bear Lake
Baldwin Lake
Gold Mtn
8220
SAN BERNARDINO
Redlands
Warm Cr
SANTA ANA RIVER
Mill Creek
San Gorgonio Mtn
11485
SAN BERNARDINO CO
RIVERSIDE CO
Yucaipa
Wilson Creek
San Timoteo Creek
Noble Creek
San Gorgonio
Whitewater
COACHELLA VALLEY
TO INDIO
Beaumont
San Gorgonio Pass
Banning
River
MARCH A F B
SAN JACINTO RIVER
Potrero Cr
San Jacinto Pk
10805
Tahquitz Pk
8826
Perris
San Jacinto
Hemet
Railroad Canyon Reservoir
Lake Elsinore
Bautista
Strawberry
North Fork
South Fork
Lake Hemet Reservoir
Thomas Mtn
6812
Cahuila Mtn
5624
Lookout Mtn
5590
RIVERSIDE
SAN DIEGO
CO
CO
Santa Margarita River
TO SAN DIEGO
N
VICINITY MAP
OREGON
IDAHO
NEVADA
Reno
Carson City
Sacramento
San Francisco
Las Vegas
San Bernardino
Los Angeles
San Diego
MEXICO
AREA COVERED BY MAP
LEGEND
BOUNDARY OF DRAINAGE AREA
BOUNDARY OF SUBAREAS.
BOUNDARY OF INEFFECTIVE AREA.
LINE OF EQUAL PRECIPITATION IN INCHES.
NATURAL DRAINAGE IS TO THE SAN GABRIEL RIVER WITH A DIVERSION TO THE SANTA ANA RIVER.
SCALE IN MILES
5 0 5 10
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II-GENERAL DESIGN MEMORANDUM
ISOHYETS
MAXIMUM 24 hr. PRECIPITATION
STORM OF JANUARY 21-24, 1943
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-14

1

2

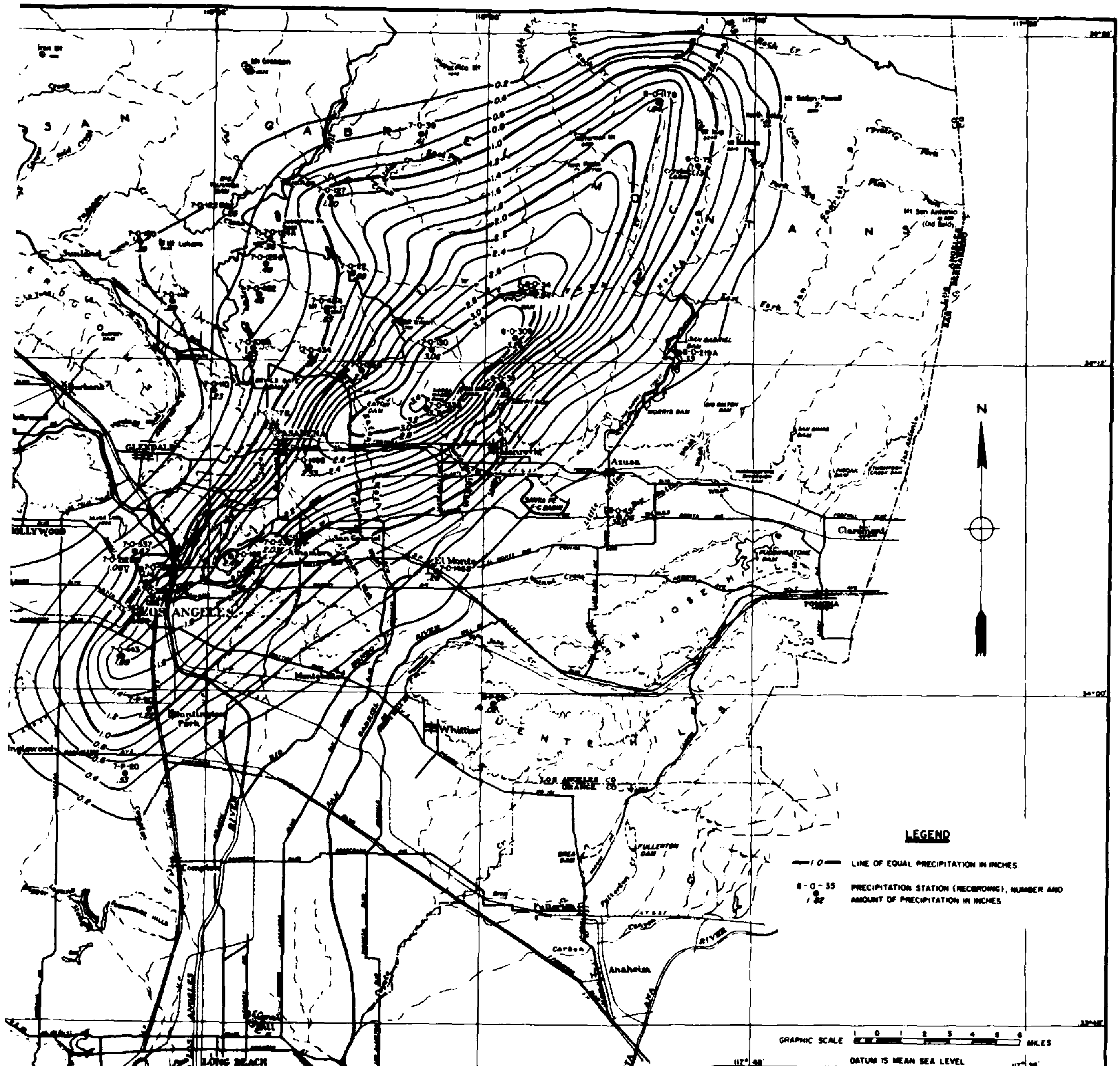


STATIONS REQUIRED FOR THE DETERMINATION OF ISOHYETS WHERE RECORDED PRECIPITATION DEPTHS WERE LESS THAN 1 INCH IN 3 HOURS

STATION	
NUMBER	NAME
7-0-22	OPID'S CAMP - CAMP SINGER
7-0-30	LOOMIS RANCH - ALDER CREEK
7-0-59	HANCOCK PARK
7-0-102B	BEVERLY HILLS - NEW CITY HALL
7-0-108A	ARROYO SECO FLOOD HEADQUARTERS
7-0-110	FLINTRIDGE FIRE STATION
7-0-114	BRIGGS TERRACE - PICKENS CANYON
7-0-120	HAINES CANYON - UPPER
7-0-122B	BIG TUJUNGA DAM - NEW CARETAKER'S HOUSE
7-0-124A	CLEAR CREEK
7-0-125B	SWITZER'S CAMP
7-0-146B	EL MONTE FIRE STATION
7-0-283	BURBANK AIRPORT
7-0-434	ALTADENA COUNTY FORESTRY PARK
7-0-439	BALDWIN HILLS - STANDARD OIL FIELD OFFICE
7-0-468	PINE CANYON - ARROYO SECO
7-0-484	MT LOWE RIDGE
7-0-537	LOS ANGELES - ECHO PARK & LUCRETIA AVE.
7-P-80	LOS ANGELES - 96TH & CENTRAL AVE.
8-0-48	AZUSA - GRIFFITH
8-0-818A	SAN GABRIEL DAM NO. 1
8-P-20	PUENTE HILLS

RECORDED 15-MIN. PRECIPITATION AT STATIONS WHERE DEPTHS EXCEEDED 1 INCH IN 3 HOURS

STATION		PRECIPITATION IN INCHES ON MARCH 3-4 BY 15-MIN. PERIODS ENDING AS SHOWN												3-HR. TOTAL IN INCHES
NUMBER	NAME	2215	2230	2245	2300	2315	2330	2345	0000	0015	0030	0045	0100	
7-0-28A	LOS ANGELES - U.S.W.B. - 5TH & MAIN STS.	0.23	0.30	0.21	0.19	0.26	0.06	0.00	0.01	0.01	0.03	0	0	1.40
7-0-28B	LOS ANGELES - U.S.W.B. - 3RD & SPRING STS.	0.11	0.35	0.20	0.16	0.20	0.11	0.02	0.06	0.05	0.02	0.01	0	1.62
7-0-127	COLBY RANCH - SLEEPY HOLLOW RANCH	0.10	0.09	0.04	0.02	0.08	0.10	0.10	0.08	0.14	0.15	0.09	0.20	1.30
7-0-130	HOEGEE'S CAMP	0.13	0.16	0.22	0.11	0.37	0.30	0.36	0.48	0.49	0.35	0.16	0.03	3.06
7-0-125B	SIERRA MADRE - CARTER	0.10	0.03	0.01	0.04	0.12	0.10	0.07	0.09	0.49	0.37	1.30	0.44	3.32
7-0-136B	HENNINGER FLATS	0.12	0.09	0.10	0.10	0.40	0.23	0.32	0.21	0.21	0.21	0.02	0.02	2.10
7-0-137B	PASADENA - METEOROLOGICAL STATION	0.01	0.01	0.11	0.11	0.01	0.07	0.15	0.05	0.11	0.09	0.05	0.09	1.08
7-0-140B	CALIFORNIA TECH.	0.01	0.15	0.10	0.23	0.40	0.52	0.50	0.44	0.15	0.01	0.05	0.02	2.53
7-0-162	EL SERENO	0.01	0.10	0.02	0.26	0.06	0.32	0.30	0.34	0.11	0.01	0	0.01	2.40
7-0-216B	BARLOW SANITORIUM - L.A. CITY	0.05	0.31	0.15	0.05	0.16	0.27	0.05	0.05	0	0.01	0	0	1.06
7-0-443	LOS ANGELES - 30TH & TRINITY STS.	0.21	0.40	0.20	0.40	0.20	0.02	0.15	0.01	0	0.01	0.01	0	1.90
7-0-530	LOS ANGELES - BOYLSTON ST.	0.05	0.30	0.16	0.09	0.15	0.17	0.04	0.17	0.05	0.02	0	0	1.14
7-0-580	LOS ANGELES - STOCKBRIDGE AVE.	0.05	0.16	0.42	0.29	0.40	0.30	0.34	0.12	0	0	0	0.01	2.05
7-P-90	LOS ANGELES - SLAUSON & LONG BEACH AVE.	0.12	0.40	0.20	0.16	0.20	0.25	0.16	0.14	0.05	0	0	0	1.82
8-0-34	SAN GABRIEL DAM NO. 2	0.10	0.04	0.16	0.14	0.14	0.42	0.32	0.12	0.40	0.35	0.32	0.32	2.94
8-0-35	MONROVIA FALLS	0.05	0.12	0.10	0.10	0.27	0.13	0	0.01	0	0.26	0.70	0.04	1.62
8-0-75	CRYSTAL LAKE CO. PARK - E. PINE FLAT	0.07	0.05	0.05	0.10	0.12	0.15	0.05	0.25	0.07	0.02	0.01	0.09	1.13
8-0-117B	STATE PRISON CAMP NO. 37	0.00	0.00	0.15	0.14	0.20	0.20	0.15	0.23	0.14	0.17	0.15	0.10	1.84
8-0-280	SANTA ANITA - SPRING CAMP	0.11	0.05	0.14	0.31	0.35	0.05	0.00	0.12	0.50	0.50	0.02	0.15	3.26



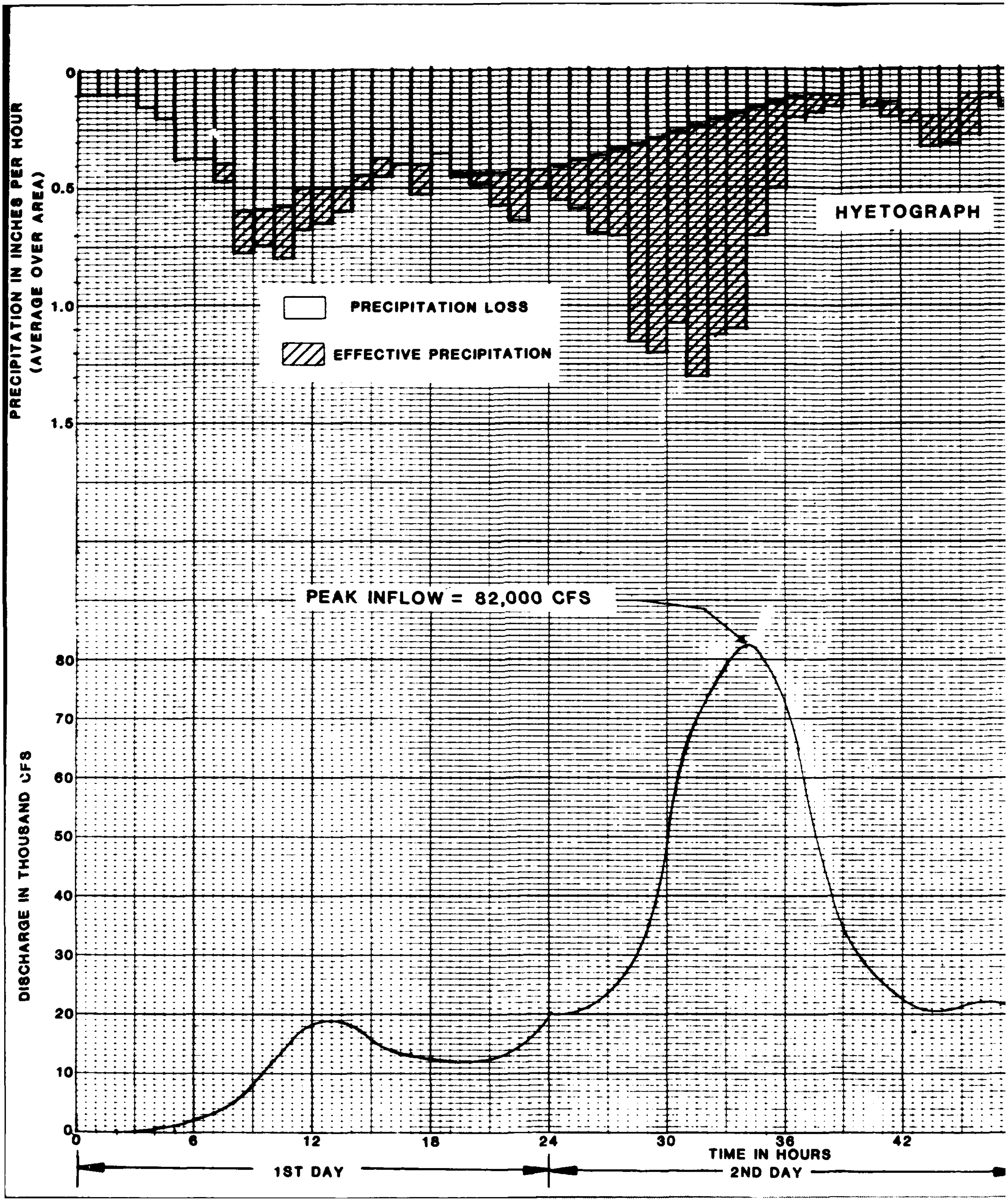
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II-GENERAL DESIGN MEMORANDUM

ISOHYETS
MAXIMUM 3-HOUR PRECIPITATION
THUNDERSTORM OF MARCH 3-4, 1943
AND TABULATION OF PRECIPITATION AT VARIOUS STATIONS

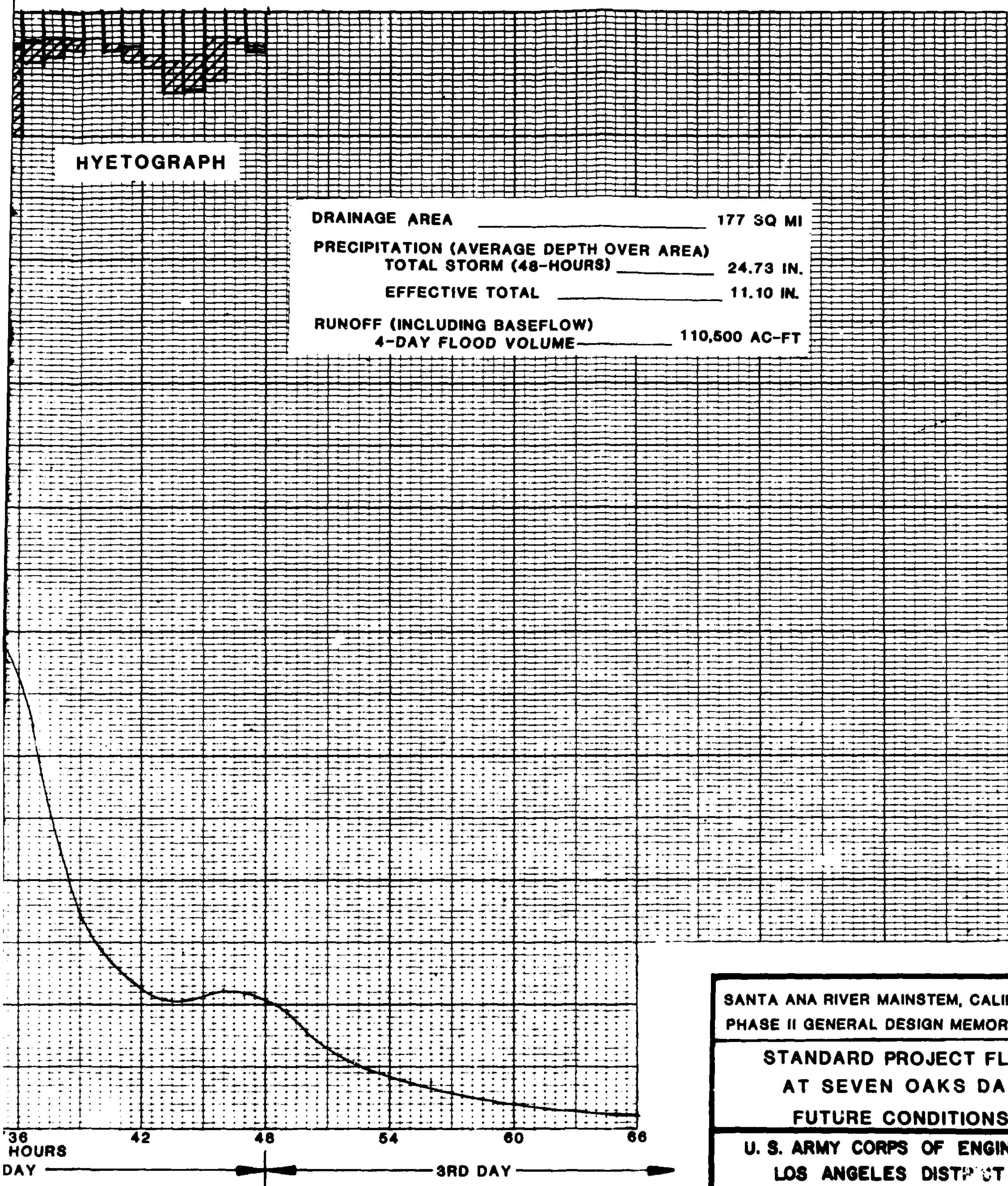
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-15

2



PRECIPITATION IN INCHES PER HOUR (AVERAGE OVER AREA)
0
0.5
1.0
1.5
HYETOGRAPH
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
PEAK INFLOW = 82,000 CFS
DISCHARGE IN THOUSAND CFS
80
70
60
50
40
30
20
10
0
0
6
12
18
24
30
36
42
TIME IN HOURS
1ST DAY
2ND DAY



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

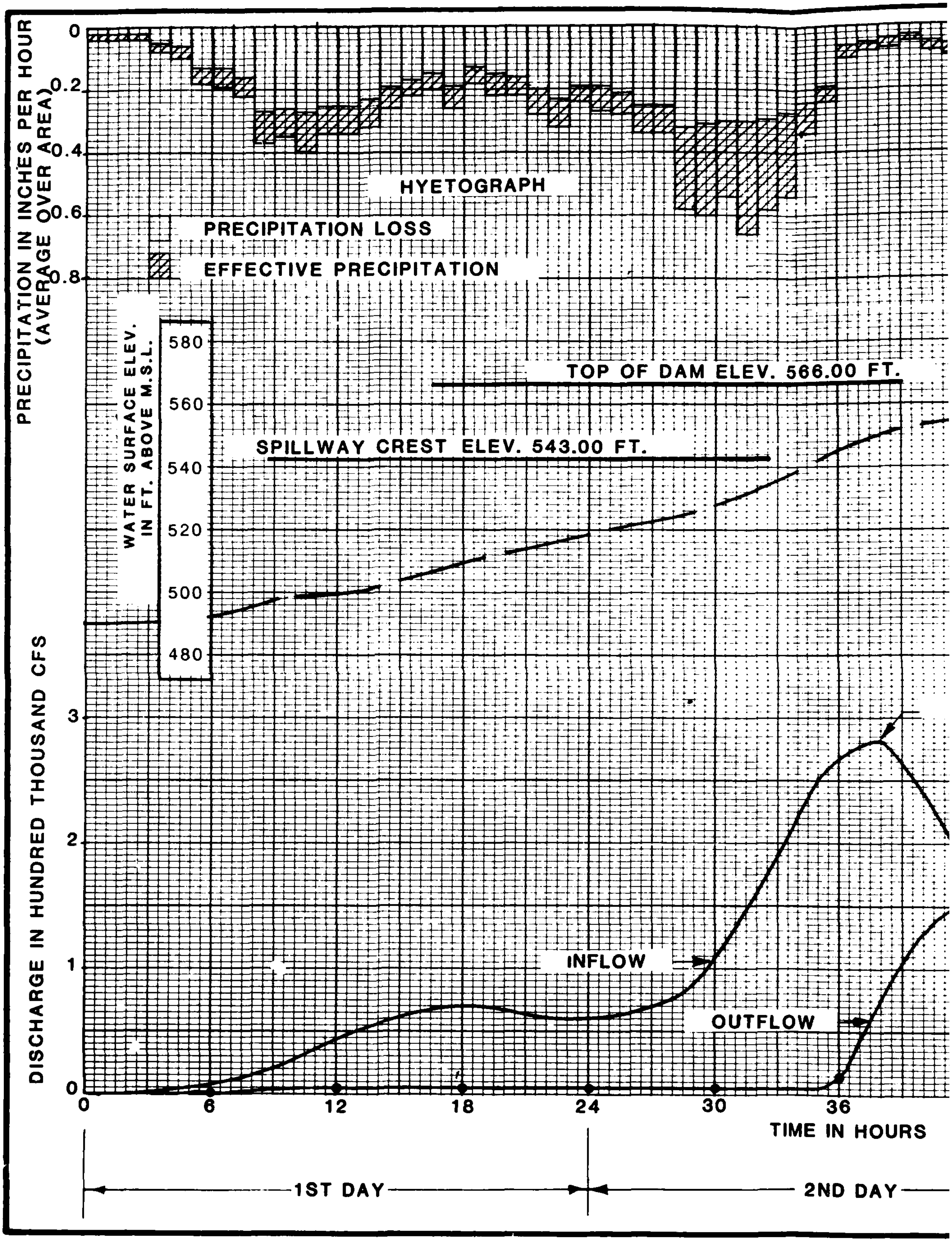
STANDARD PROJECT FLOOD
AT SEVEN OAKS DAM
FUTURE CONDITIONS

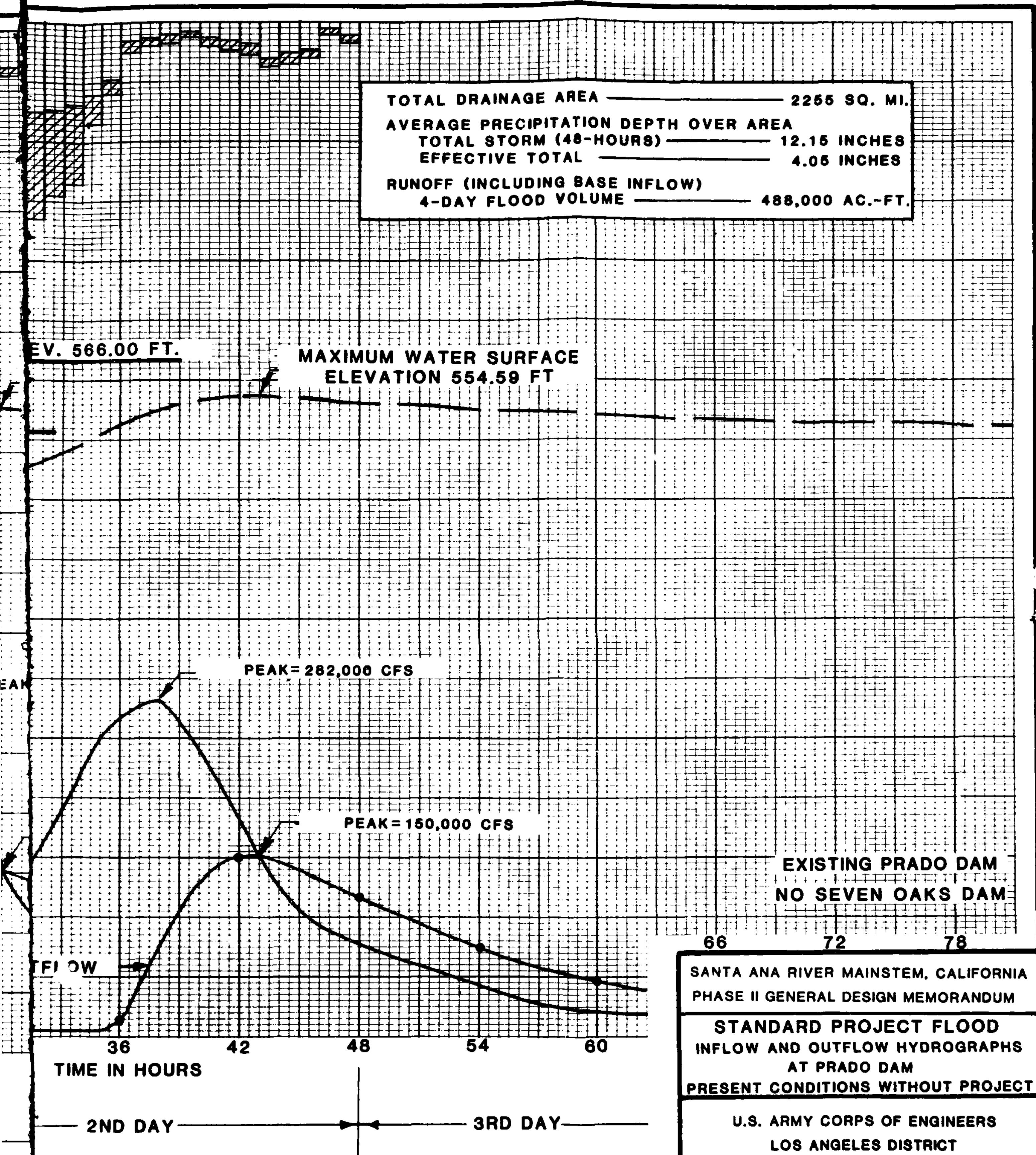
U. S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-16

1

2


PRECIPITATION IN INCHES PER HOUR (AVERAGE OVER AREA)
0
0.2
0.4
0.6
0.8
HYETOGRAPH
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
WATER SURFACE ELEV. IN FT. ABOVE M.S.L.
580
560
540
520
500
480
TOP OF DAM ELEV. 566.00 FT.
SPILLWAY CREST ELEV. 543.00 FT.
DISCHARGE IN HUNDRED THOUSAND CFS
3
2
1
0
INFLOW
OUTFLOW
0
6
12
18
24
30
36
TIME IN HOURS
1ST DAY
2ND DAY



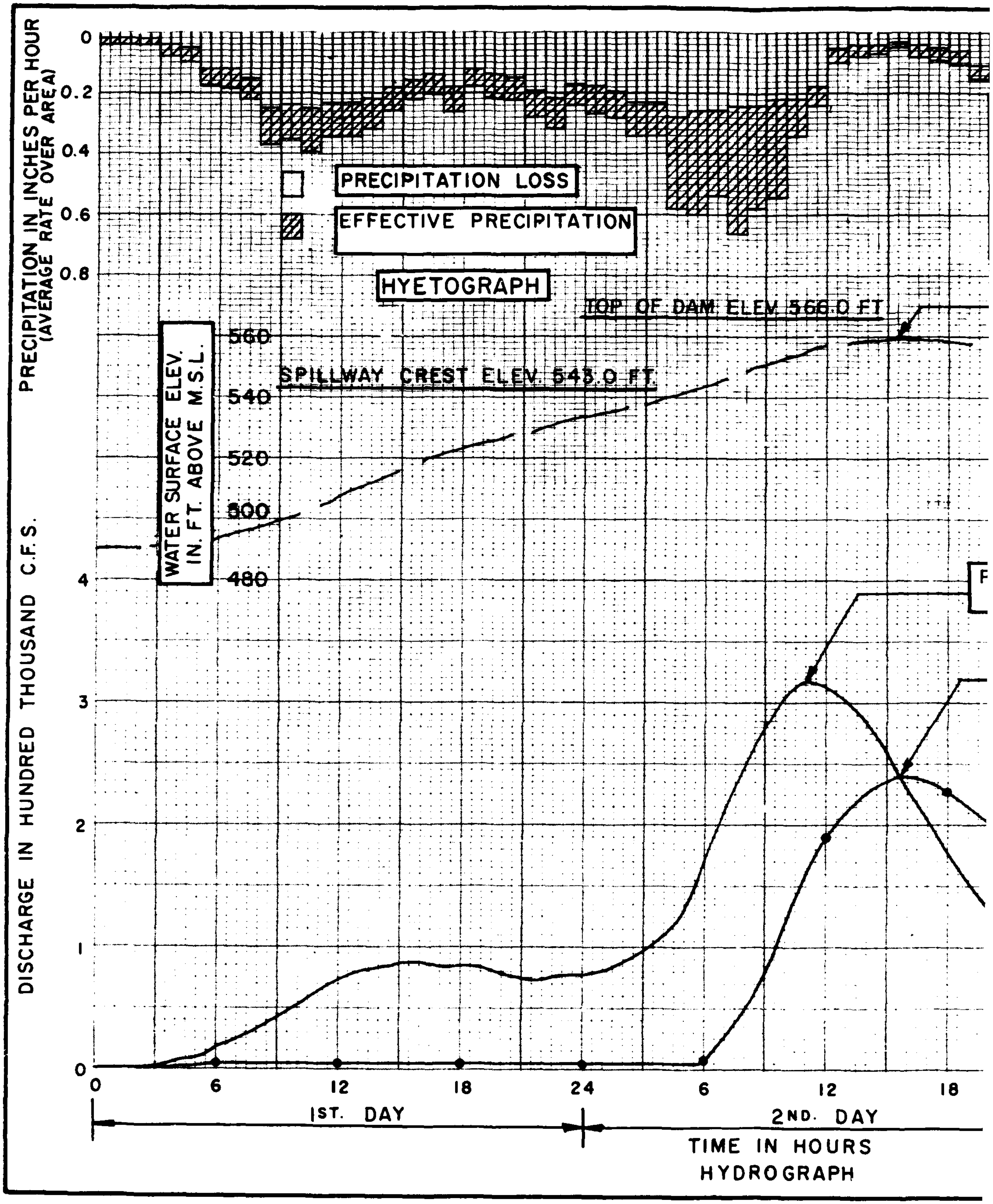
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

STANDARD PROJECT FLOOD
INFLOW AND OUTFLOW HYDROGRAPHS
AT PRADO DAM
PRESENT CONDITIONS WITHOUT PROJECT

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

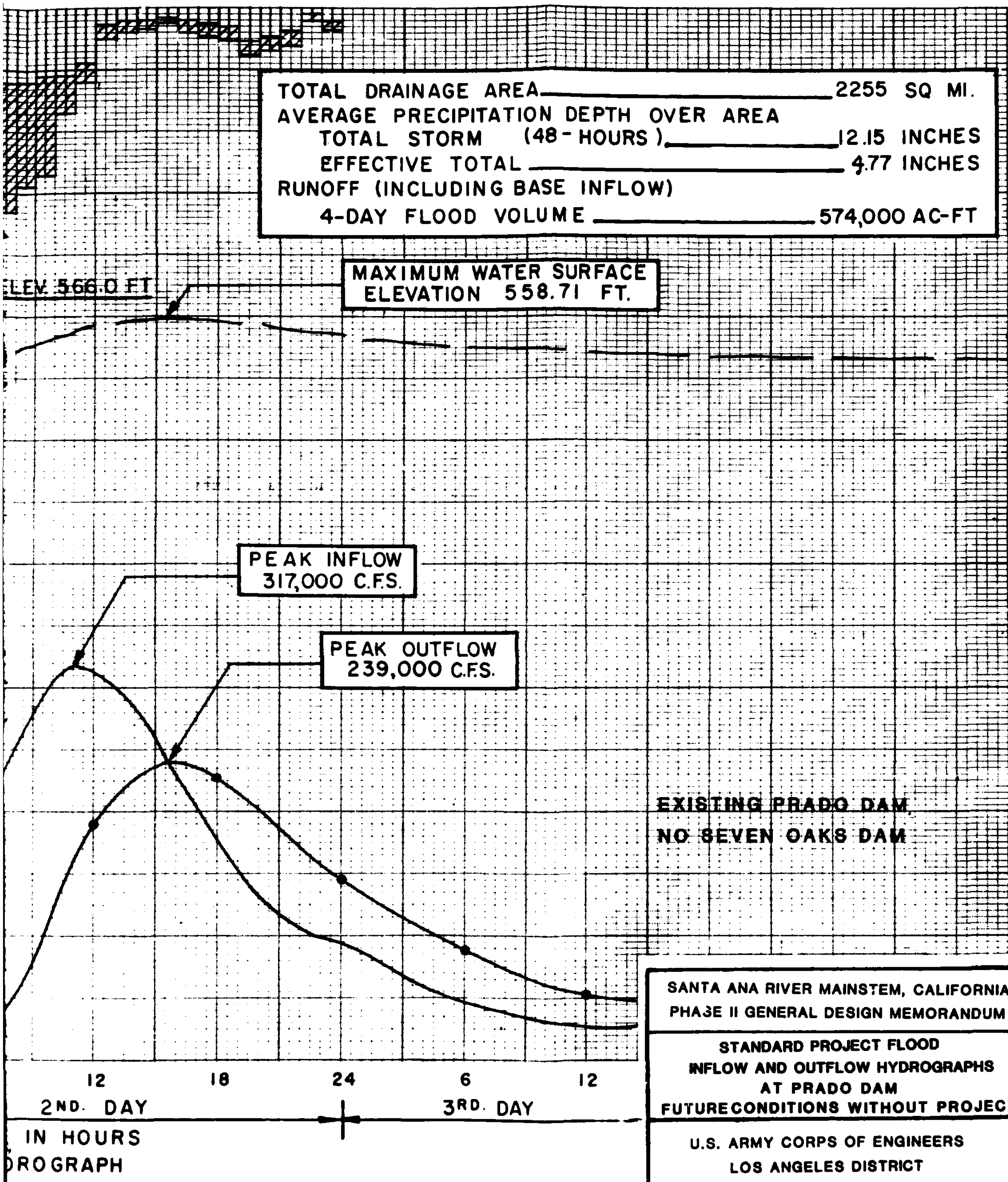
PLATE 7-17

2.



PRECIPITATION IN INCHES PER HOUR (AVERAGE RATE OVER AREA)
0
0.2
0.4
0.6
0.8
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
HYETOGRAPH
TOP OF DAM ELEV 566.0 FT
WATER SURFACE ELEV. IN. FT. ABOVE M.S.L.
560
540
520
500
480
SPILLWAY CREST ELEV. 543.0 FT.
DISCHARGE IN HUNDRED THOUSAND C.F.S.
4
3
2
1
0
0
6
12
18
24
6
12
18
1ST. DAY
2ND. DAY
TIME IN HOURS
HYDROGRAPH

1

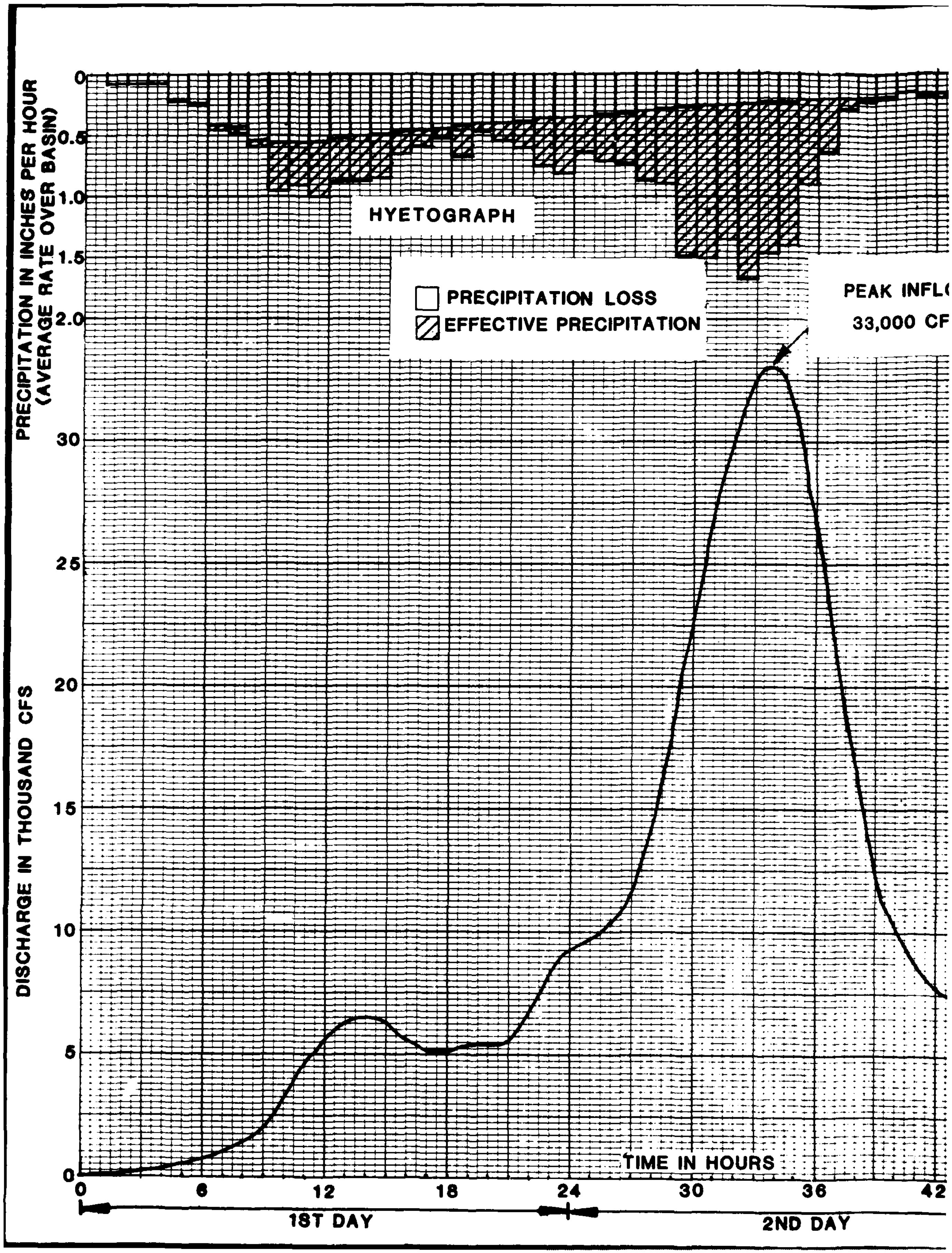


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

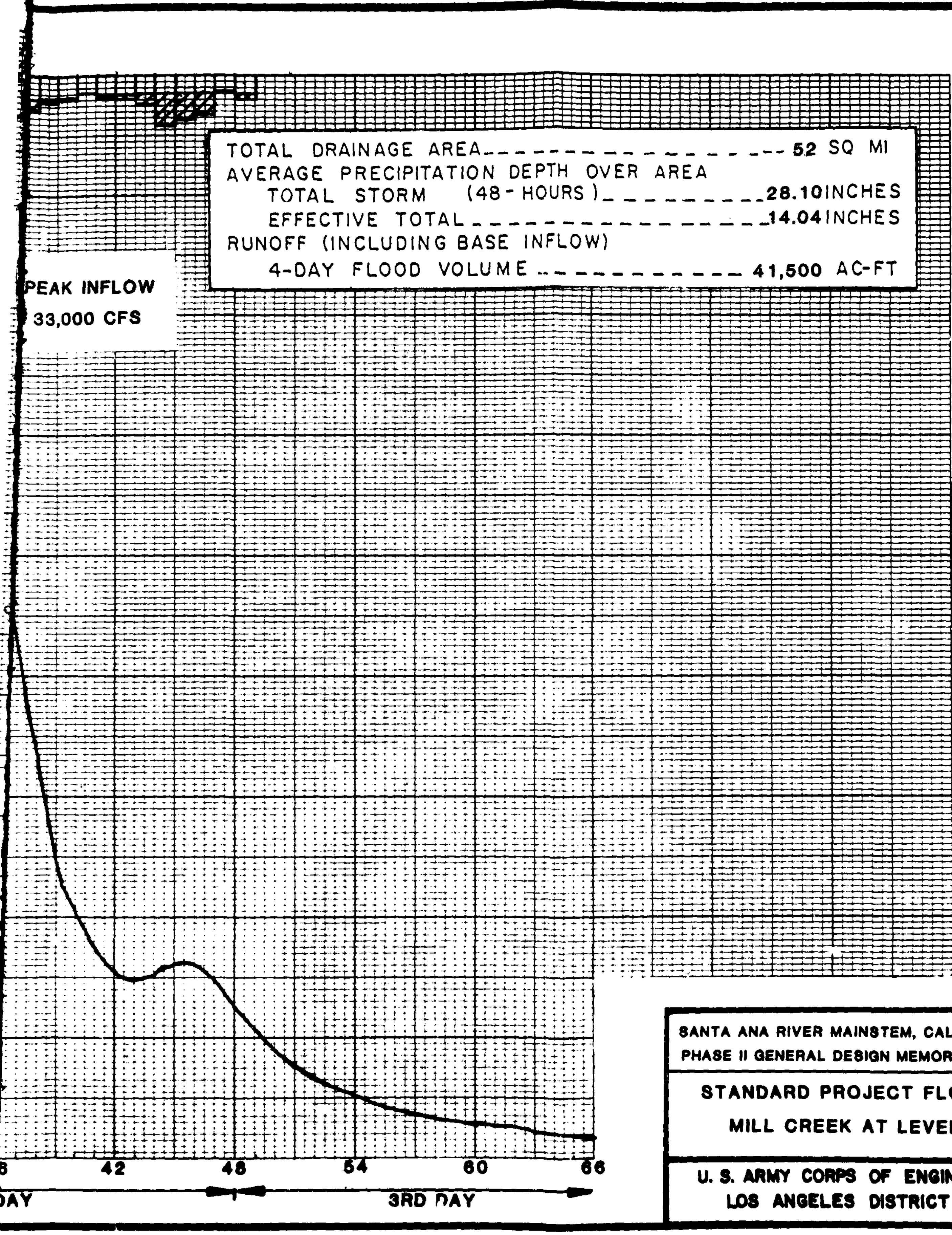
STANDARD PROJECT FLOOD
INFLOW AND OUTFLOW HYDROGRAPHS
AT PRADO DAM
FUTURE CONDITIONS WITHOUT PROJECT

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-18



PRECIPITATION IN INCHES PER HOUR
(AVERAGE RATE OVER BASIN)
0
0.5
1.0
1.5
2.0
HYETOGRAPH
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
PEAK INFL
33,000 CF
DISCHARGE IN THOUSAND CFS
30
25
20
15
10
5
0
TIME IN HOURS
0
6
12
18
24
30
36
42
1ST DAY
2ND DAY

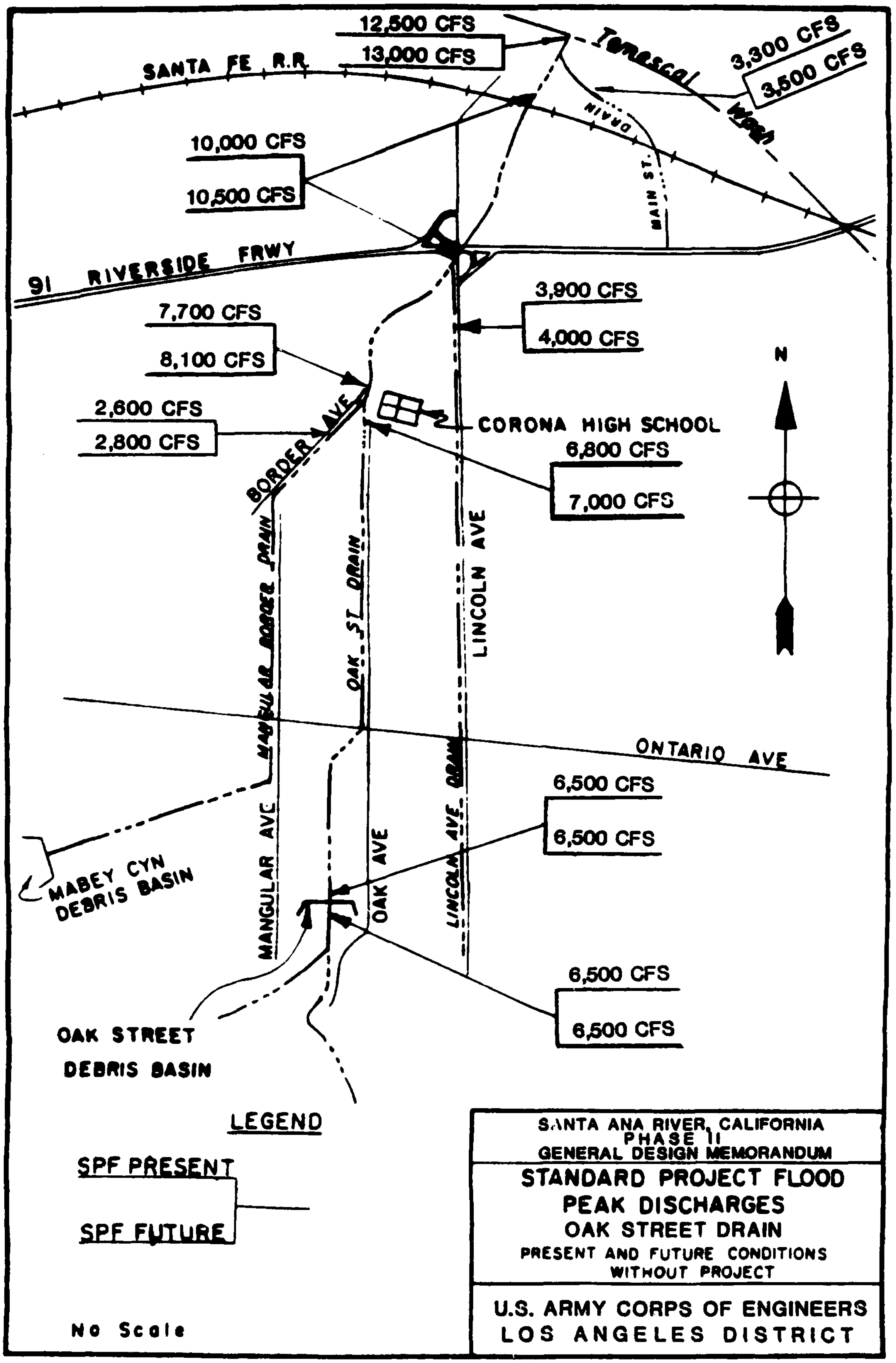


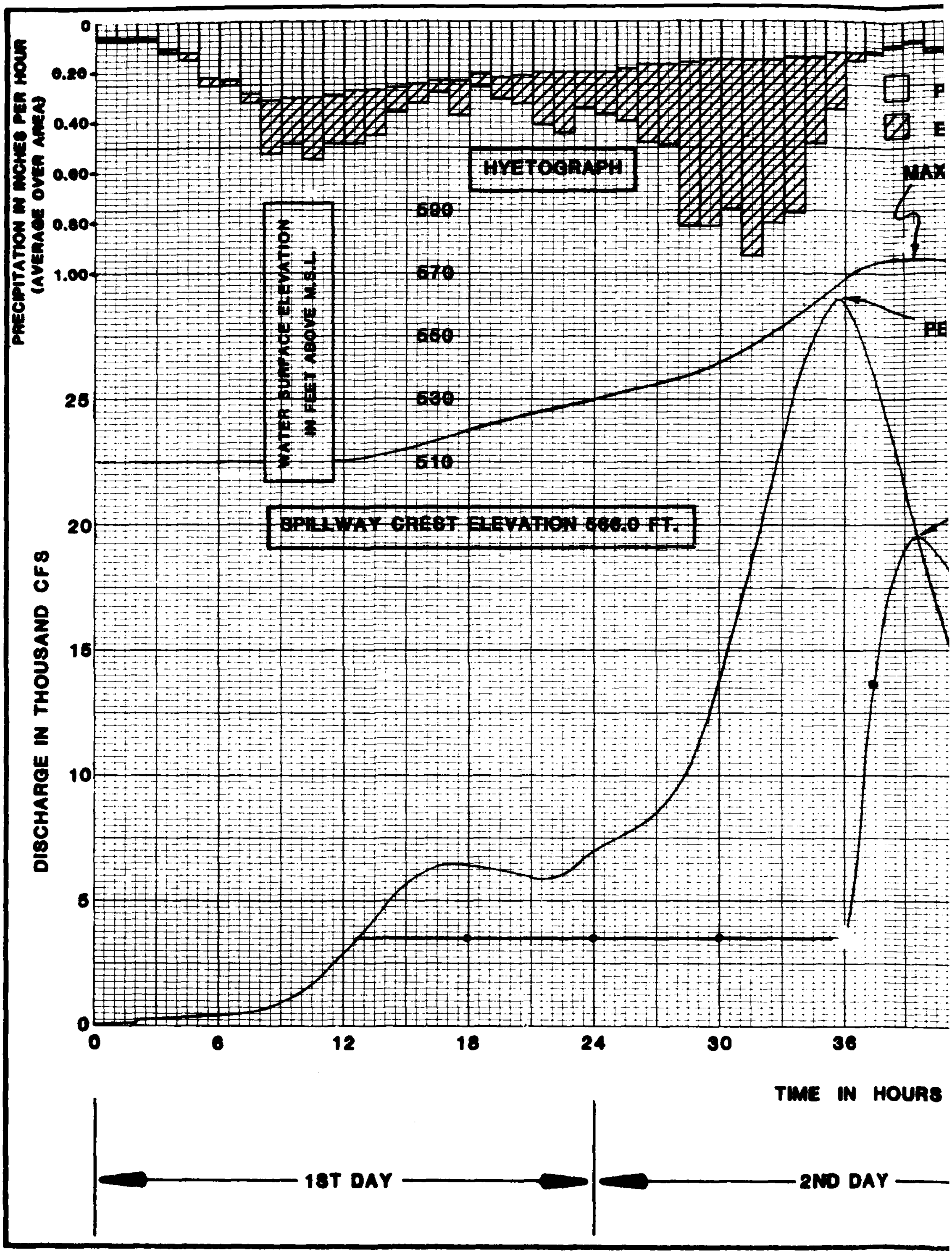
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

STANDARD PROJECT FLOOD
MILL CREEK AT LEVEE

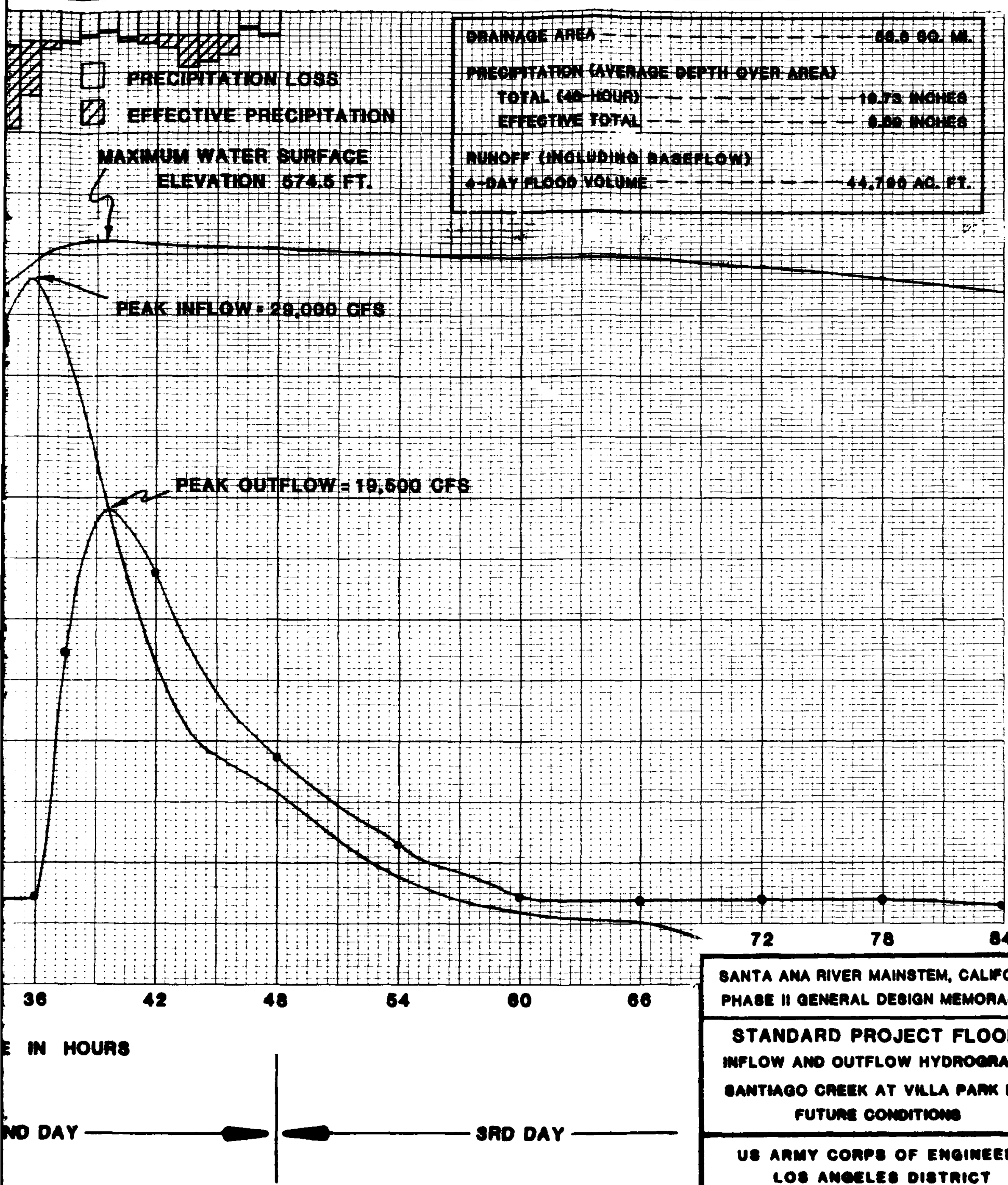
U. S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

2


12,500 CFS
13,000 CFS
SANTA FE R.R.
Temescal Wash
3,300 CFS
3,500 CFS
DRAIN
MAIN ST.
10,000 CFS
10,500 CFS
91 RIVERSIDE FRWY
3,900 CFS
4,000 CFS
7,700 CFS
8,100 CFS
N
2,600 CFS
2,800 CFS
CORONA HIGH SCHOOL
6,800 CFS
7,000 CFS
BORDER AVE
MANGULAR BORDER DRAIN
OAK ST DRAIN
LINCOLN AVE
ONTARIO AVE
6,500 CFS
6,500 CFS
MANGULAR AVE
OAK AVE
LINCOLN AVE DRAIN
MABEY CYN DEBRIS BASIN
6,500 CFS
6,500 CFS
OAK STREET DEBRIS BASIN
LEGEND
SPF PRESENT
SPF FUTURE
No Scale
SANTA ANA RIVER, CALIFORNIA
PHASE II
GENERAL DESIGN MEMORANDUM
STANDARD PROJECT FLOOD
PEAK DISCHARGES
OAK STREET DRAIN
PRESENT AND FUTURE CONDITIONS
WITHOUT PROJECT
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



PRECIPITATION IN INCHES PER HOUR (AVERAGE OVER AREA)
0
0.20
0.40
0.60
0.80
1.00
HYETOGRAPH
MAX
WATER SURFACE ELEVATION IN FEET ABOVE M.S.L.
590
570
550
530
510
PE
SPILLWAY CREST ELEVATION 566.0 FT.
DISCHARGE IN THOUSAND CFS
25
20
15
10
5
0
0
6
12
18
24
30
36
TIME IN HOURS
1ST DAY
2ND DAY



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

STANDARD PROJECT FLOOD
INFLOW AND OUTFLOW HYDROGRAPHS
SANTIAGO CREEK AT VILLA PARK DAM
FUTURE CONDITIONS

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-21

2

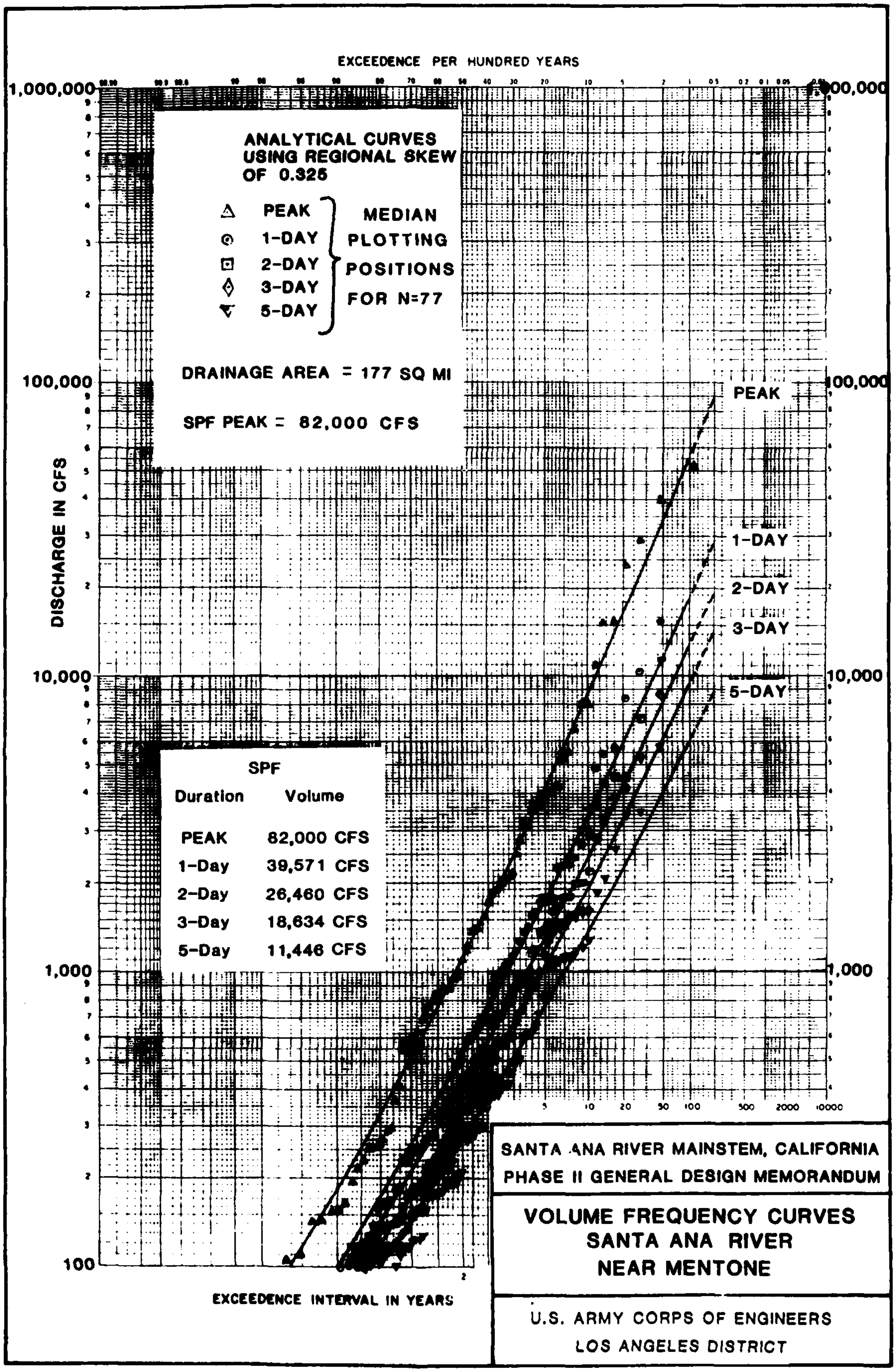
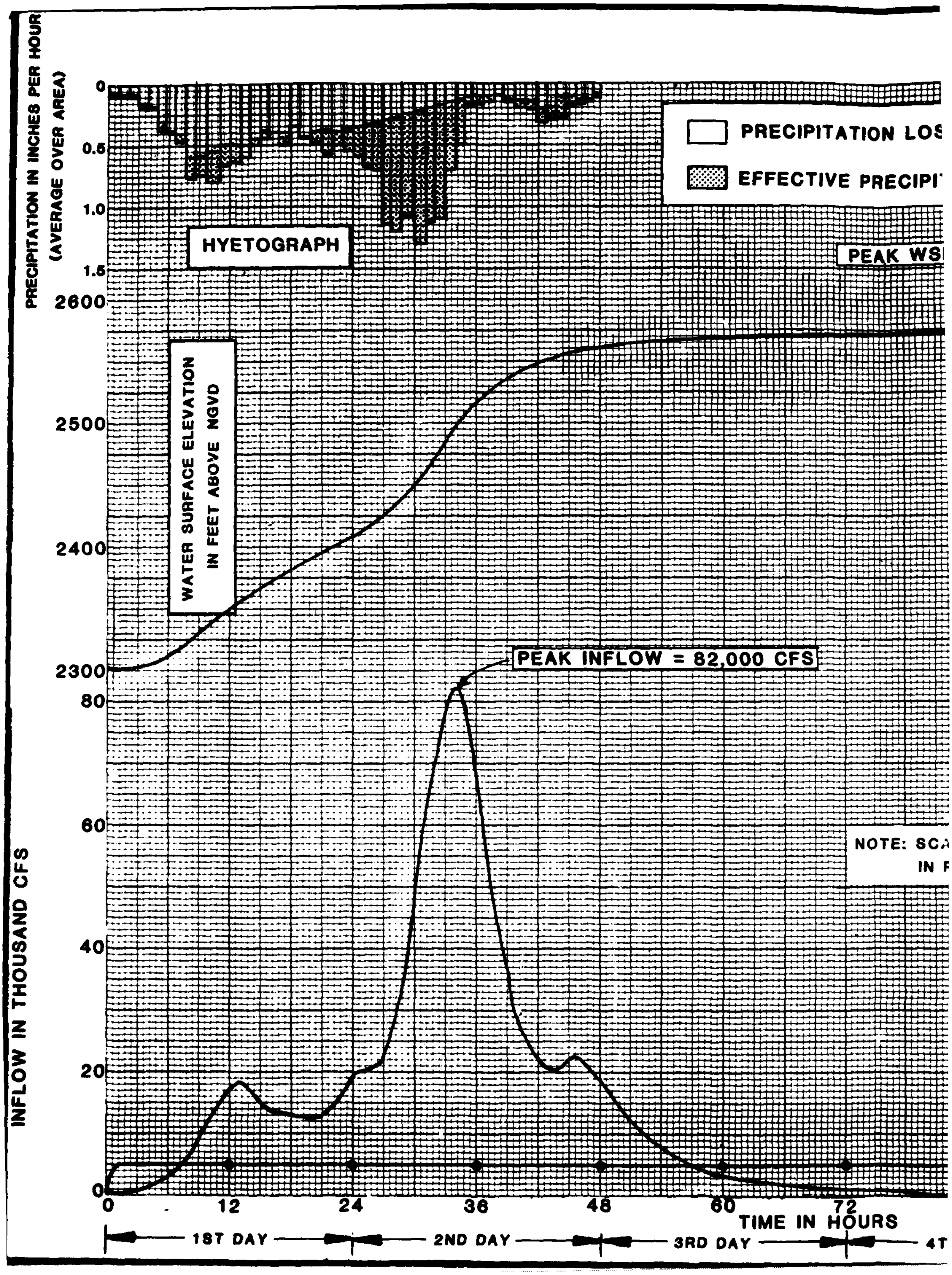
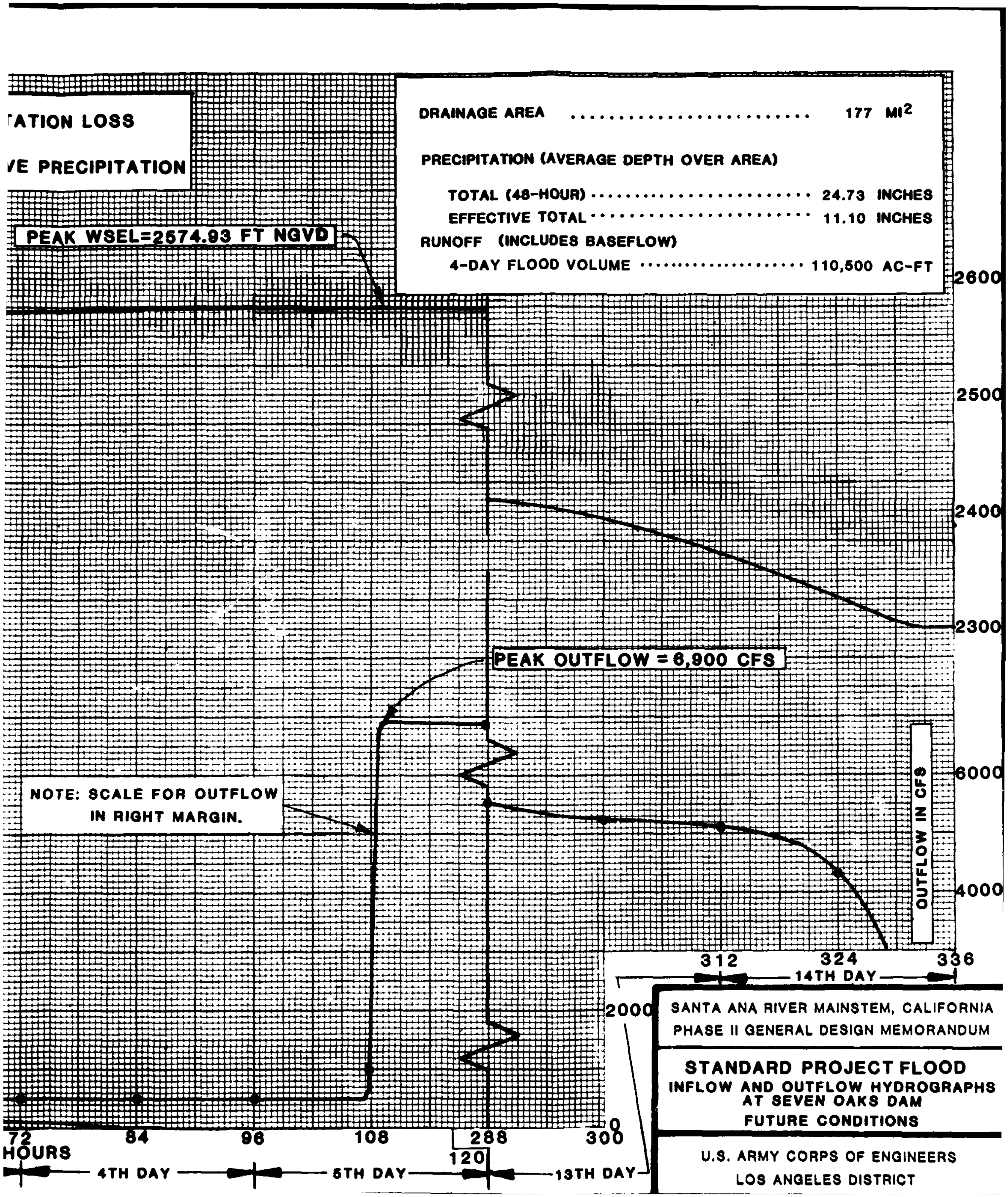

EXCEEDENCE PER HUNDRED YEARS
ANALYTICAL CURVES USING REGIONAL SKEW OF 0.325
PEAK
1-DAY
2-DAY
3-DAY
5-DAY
MEDIAN PLOTTING POSITIONS FOR N=77
DRAINAGE AREA = 177 SQ MI
SPF PEAK = 82,000 CFS
DISCHARGE IN CFS
1,000,000
100,000
10,000
1,000
100
SPF
Duration Volume
PEAK 82,000 CFS
1-Day 39,571 CFS
2-Day 26,460 CFS
3-Day 18,634 CFS
5-Day 11,446 CFS
EXCEEDENCE INTERVAL IN YEARS
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
VOLUME FREQUENCY CURVES
SANTA ANA RIVER
NEAR MENTONE
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-22

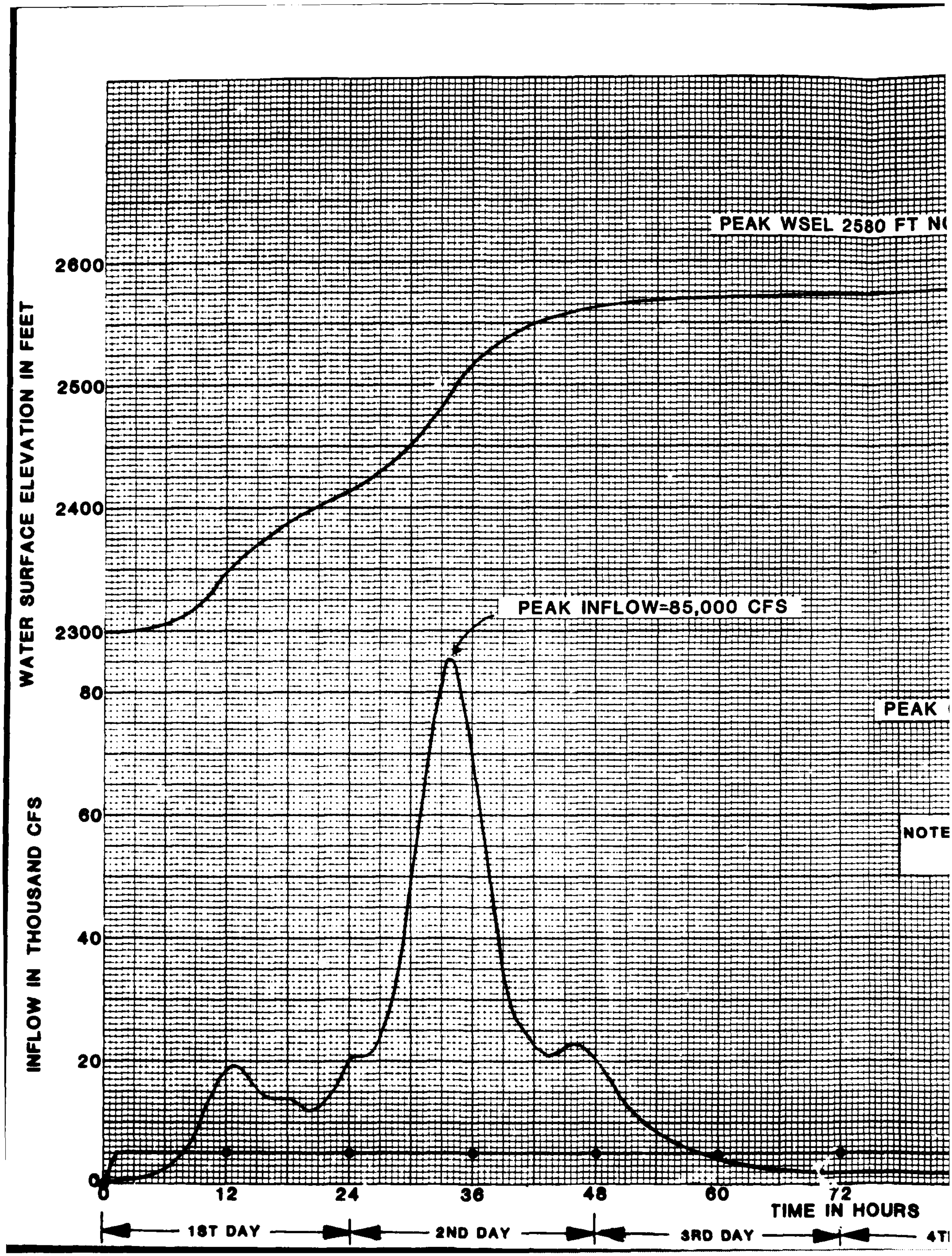

PRECIPITATION IN INCHES PER HOUR (AVERAGE OVER AREA)
0
0.5
1.0
1.5
HYETOGRAPH
PRECIPITATION LOS
EFFECTIVE PRECIPI
PEAK WS
2600
2500
2400
2300
WATER SURFACE ELEVATION IN FEET ABOVE NGVD
PEAK INFLOW = 82,000 CFS
80
60
40
20
0
INFLOW IN THOUSAND CFS
NOTE: SC
IN F
0
12
24
36
48
60
72
TIME IN HOURS
1ST DAY
2ND DAY
3RD DAY
4T

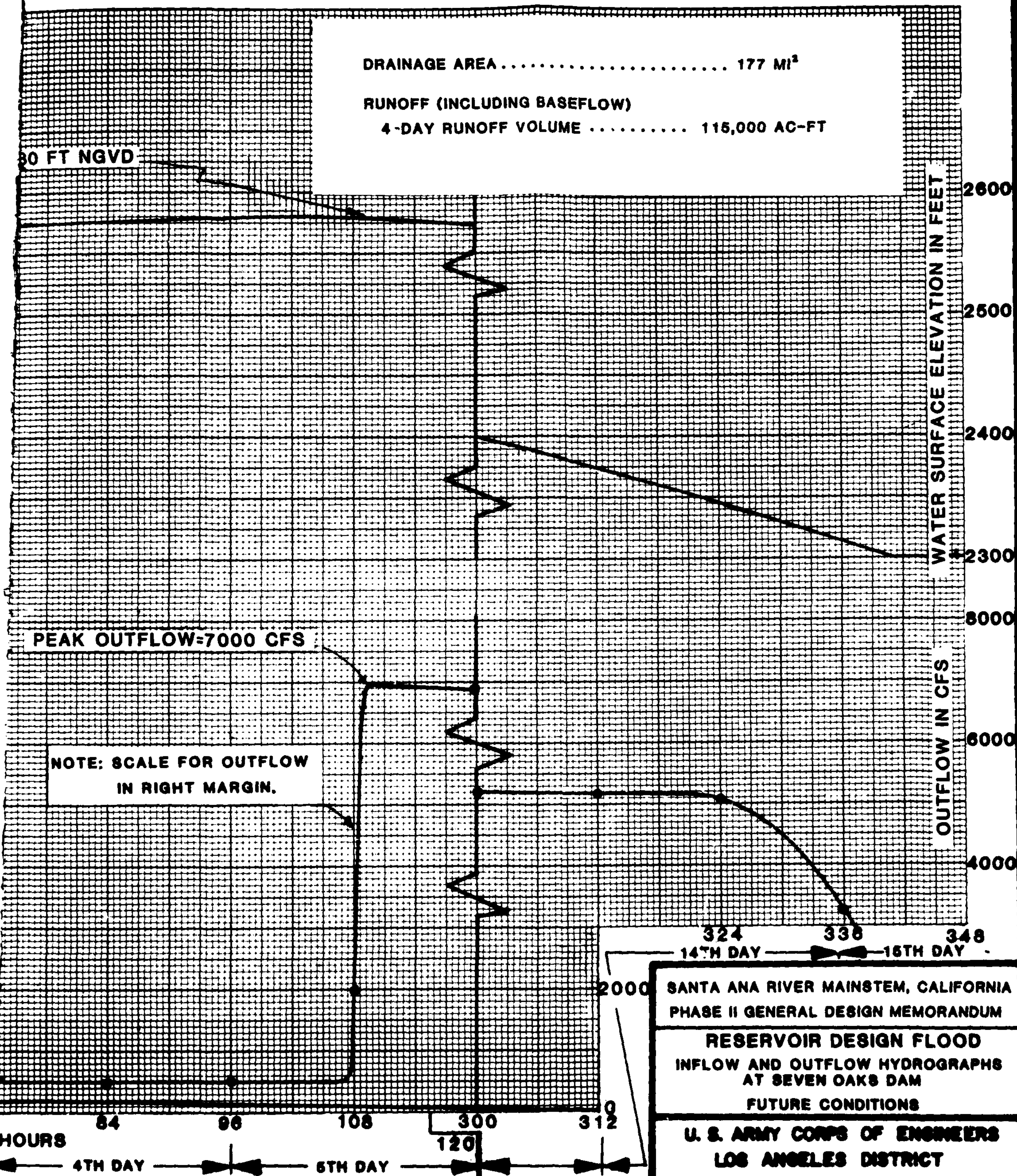


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

STANDARD PROJECT FLOOD
INFLOW AND OUTFLOW HYDROGRAPHS AT SEVEN OAKS DAM
FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


PEAK WSEL 2580 FT N
2600
2500
2400
2300
WATER SURFACE ELEVATION IN FEET
PEAK INFLOW=85,000 CFS
80
60
40
20
0
INFLOW IN THOUSAND CFS
PEAK
NOTE
0
12
24
36
48
60
72
TIME IN HOURS
1ST DAY
2ND DAY
3RD DAY
4T

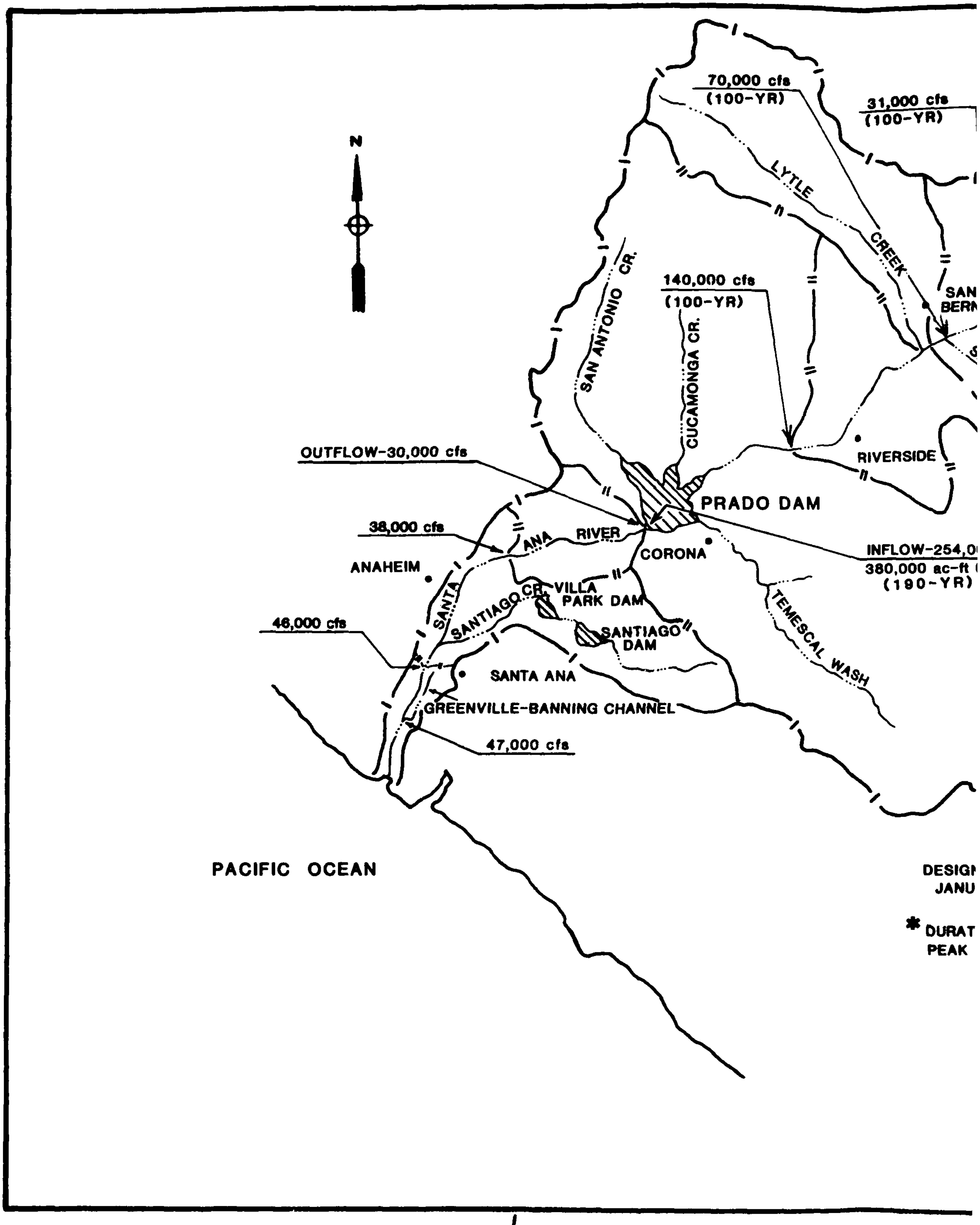


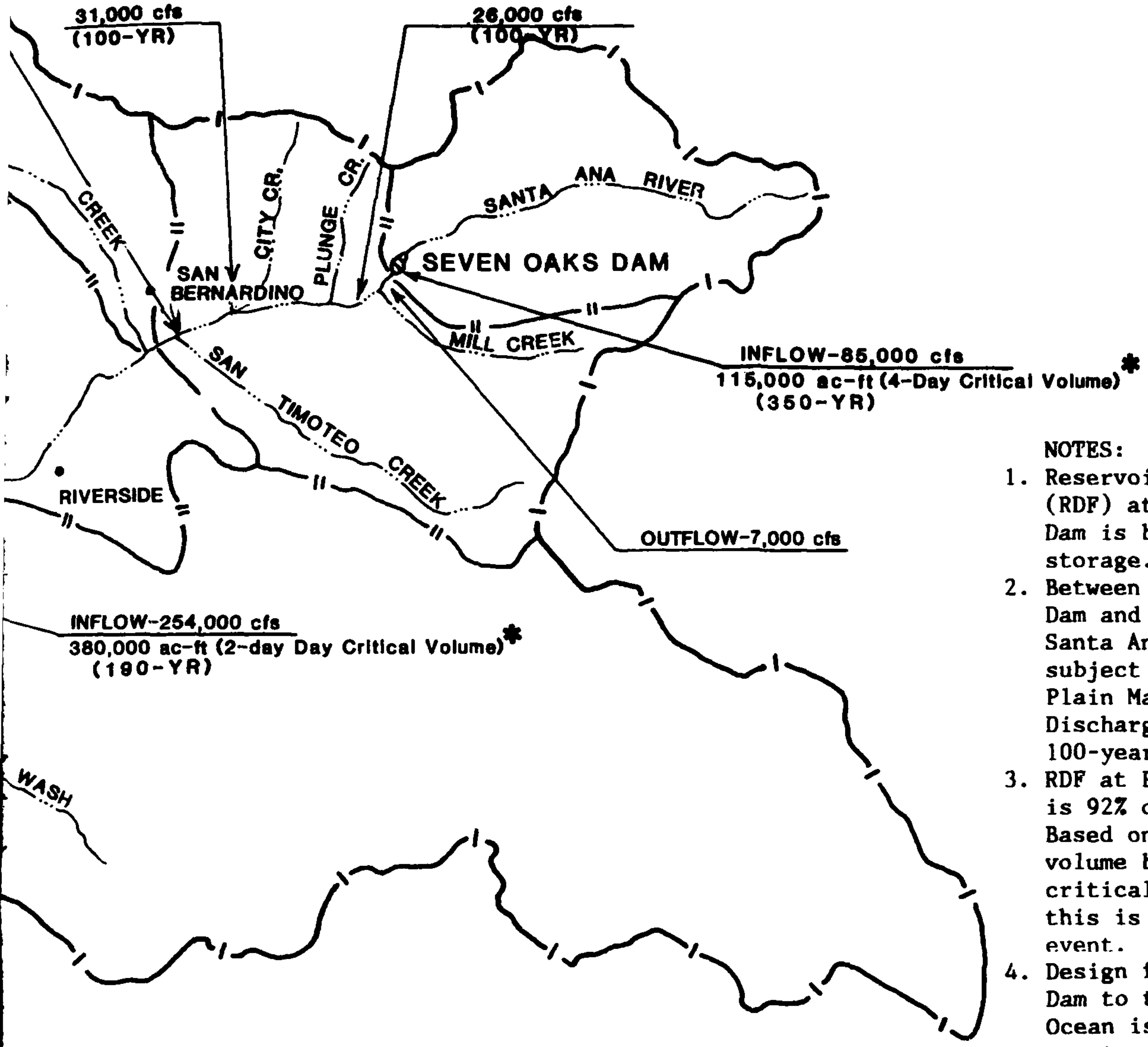
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

RESERVOIR DESIGN FLOOD
INFLOW AND OUTFLOW HYDROGRAPHS
AT SEVEN OAKS DAM
FUTURE CONDITIONS

U. S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-24


N
70,000 cfs
(100-YR)
31,000 cfs
(100-YR)
LYTLE
CREEK
SAN ANTONIO CR.
140,000 cfs
(100-YR)
CUCAMONGA CR.
SAN
BERN
RIVERSIDE
OUTFLOW-30,000 cfs
PRADO DAM
38,000 cfs
RIVER
ANA
SANTA
CORONA
INFLOW-254,0
380,000 ac-ft
(190-YR)
ANAHEIM
SANTIAGO CR.
VILLA
PARK DAM
TEMESCAL WASH
46,000 cfs
SANTIAGO
DAM
SANTA ANA
GREENVILLE-BANNING CHANNEL
47,000 cfs
PACIFIC OCEAN
DESIG
JANU
* DURAT
PEAK



NOTES:

1. Reservoir Design Flood (RDF) at Seven Oaks Dam is based on NED storage.
2. Between Seven Oaks Dam and Prado, the Santa Ana River is subject to Flood Plain Management. Discharges are 100-year frequency.
3. RDF at Prado Dam is 92% of SPF. Based on 2+ day volume being the critical duration, this is a 190-year event.
4. Design flood from Prado Dam to the Pacific Ocean is a 190-year event.

DESIGN FLOOD BASED ON OCCURENCE OF JANUARY 21-24, 1943 GENERAL STORM.

* DURATION OF CRITICAL VOLUME IS THAT WHICH GENERATED PEAK DISCHARGE AND WATER SURFACE ELEVATION

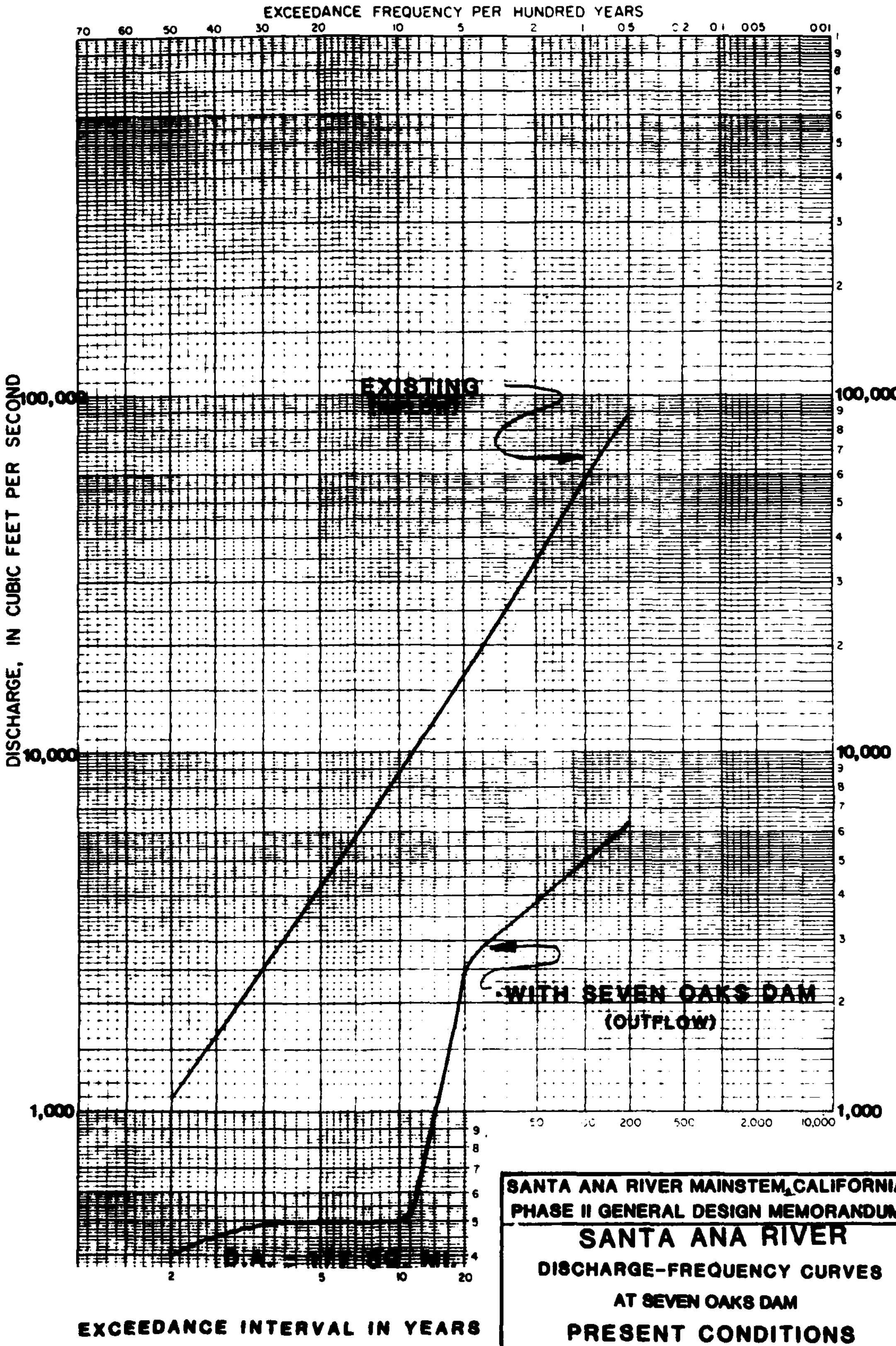
SCALE IN MILES

5 0 5 10

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGN FLOOD PEAK DISCHARGES
SANTA ANA RIVER
FUTURE CONDITIONS
WITH RECOMMENDED PLAN

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



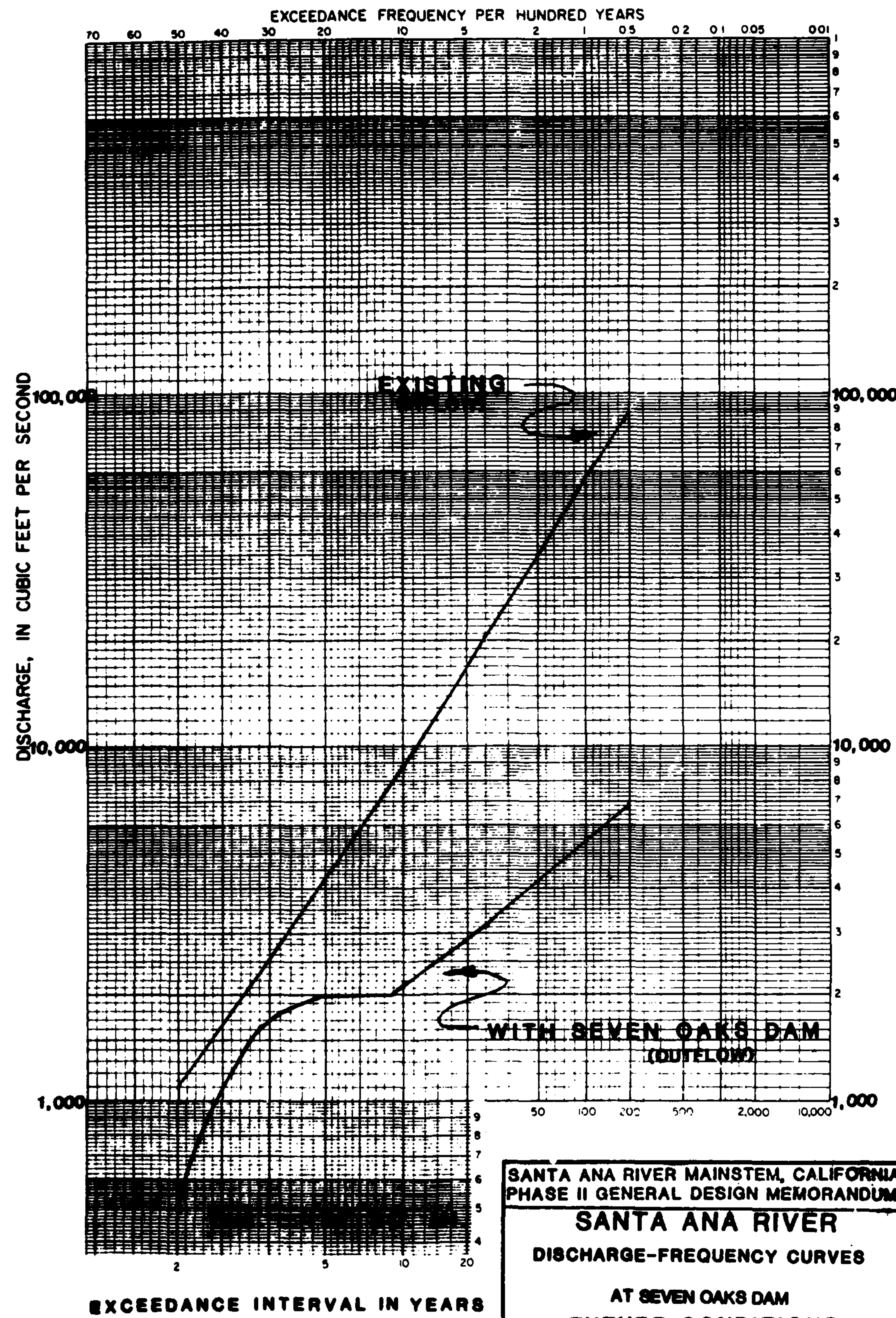
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER

DISCHARGE-FREQUENCY CURVES
AT SEVEN OAKS DAM

PRESENT CONDITIONS

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
TO ACCOMPANY REPORT DATED:



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

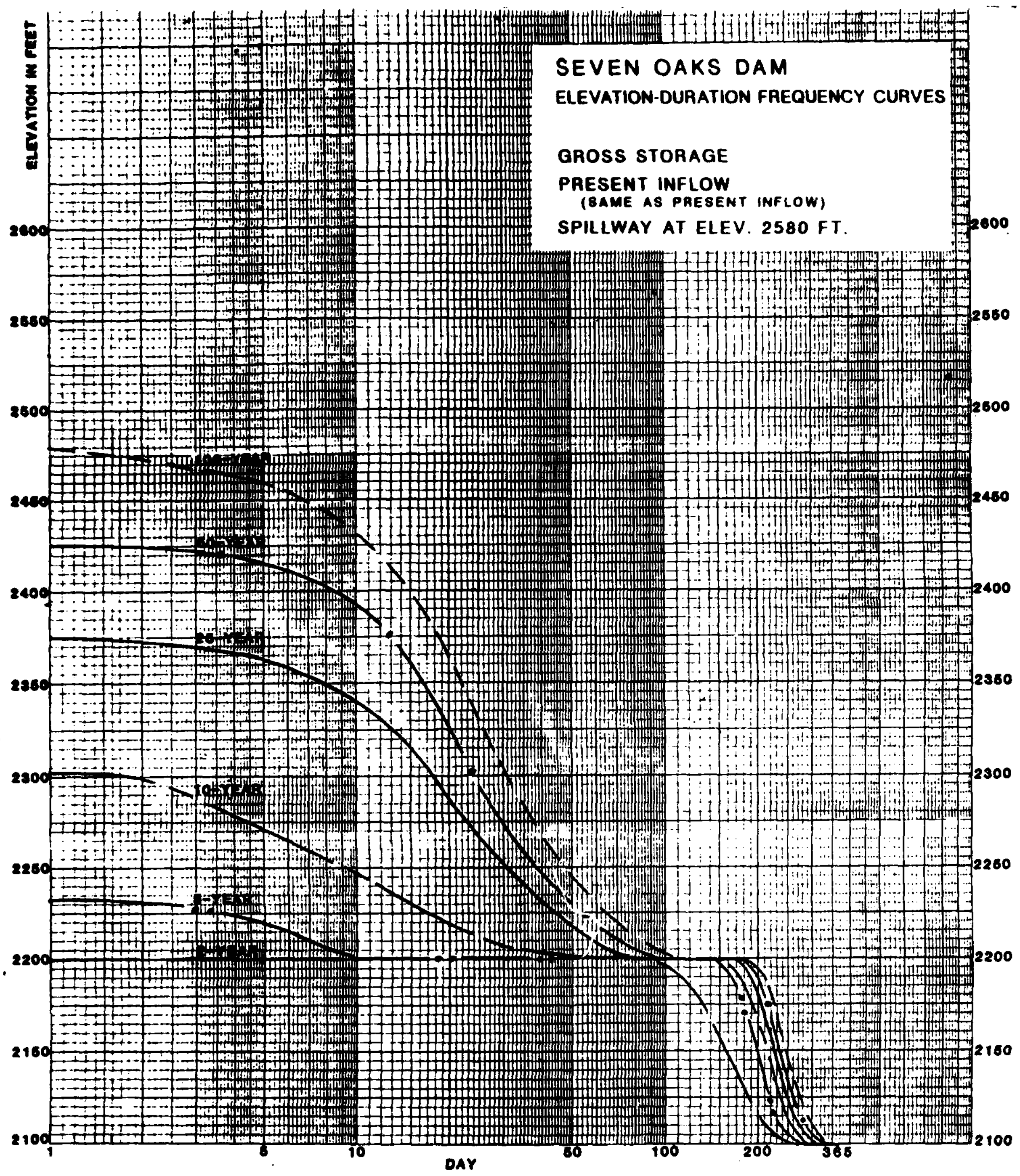
SANTA ANA RIVER

DISCHARGE-FREQUENCY CURVES

AT SEVEN OAKS DAM

FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

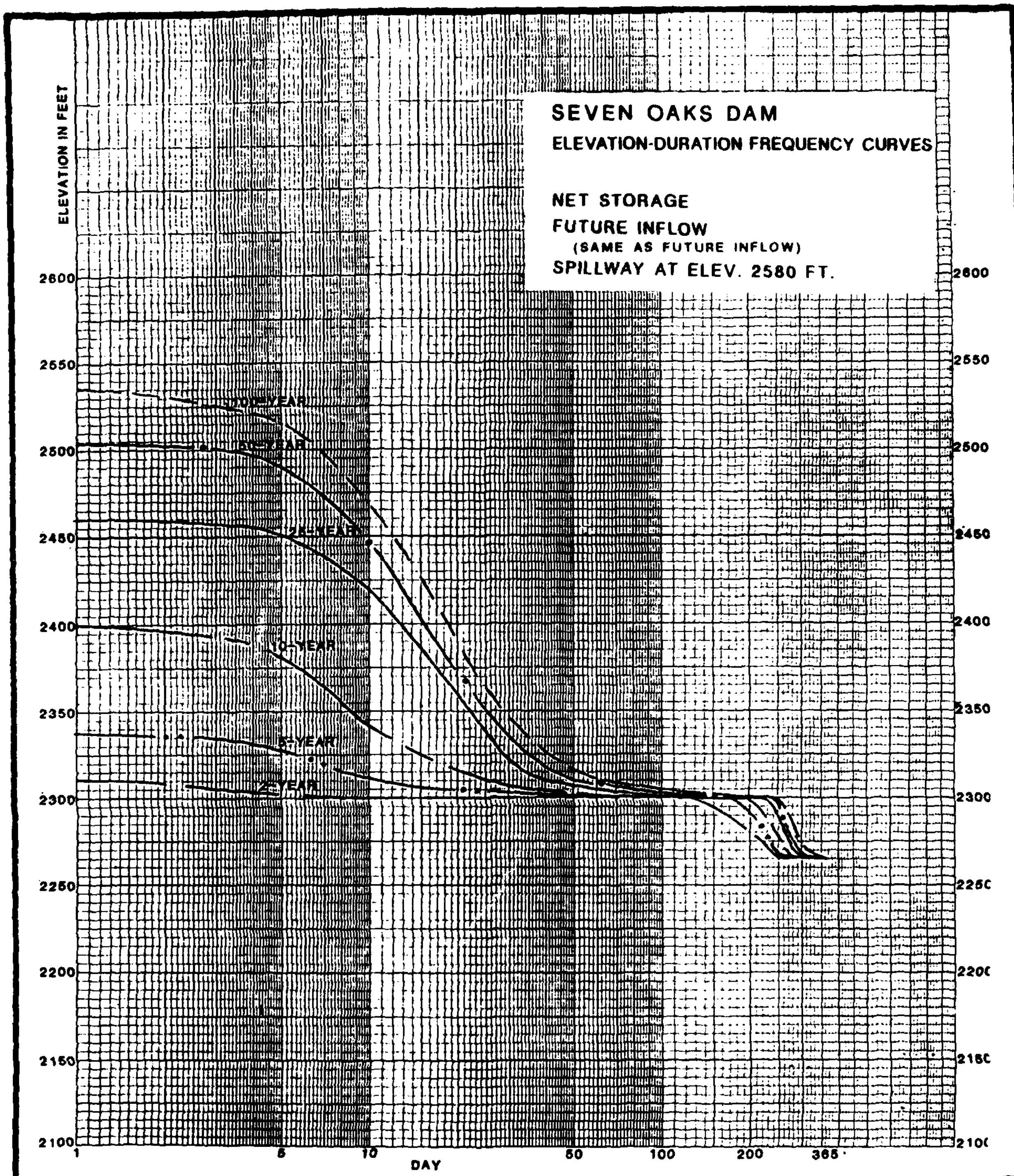


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ELEVATION- DURATION-FREQUENCY CURVES

SEVEN OAKS DAM
PRESENT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



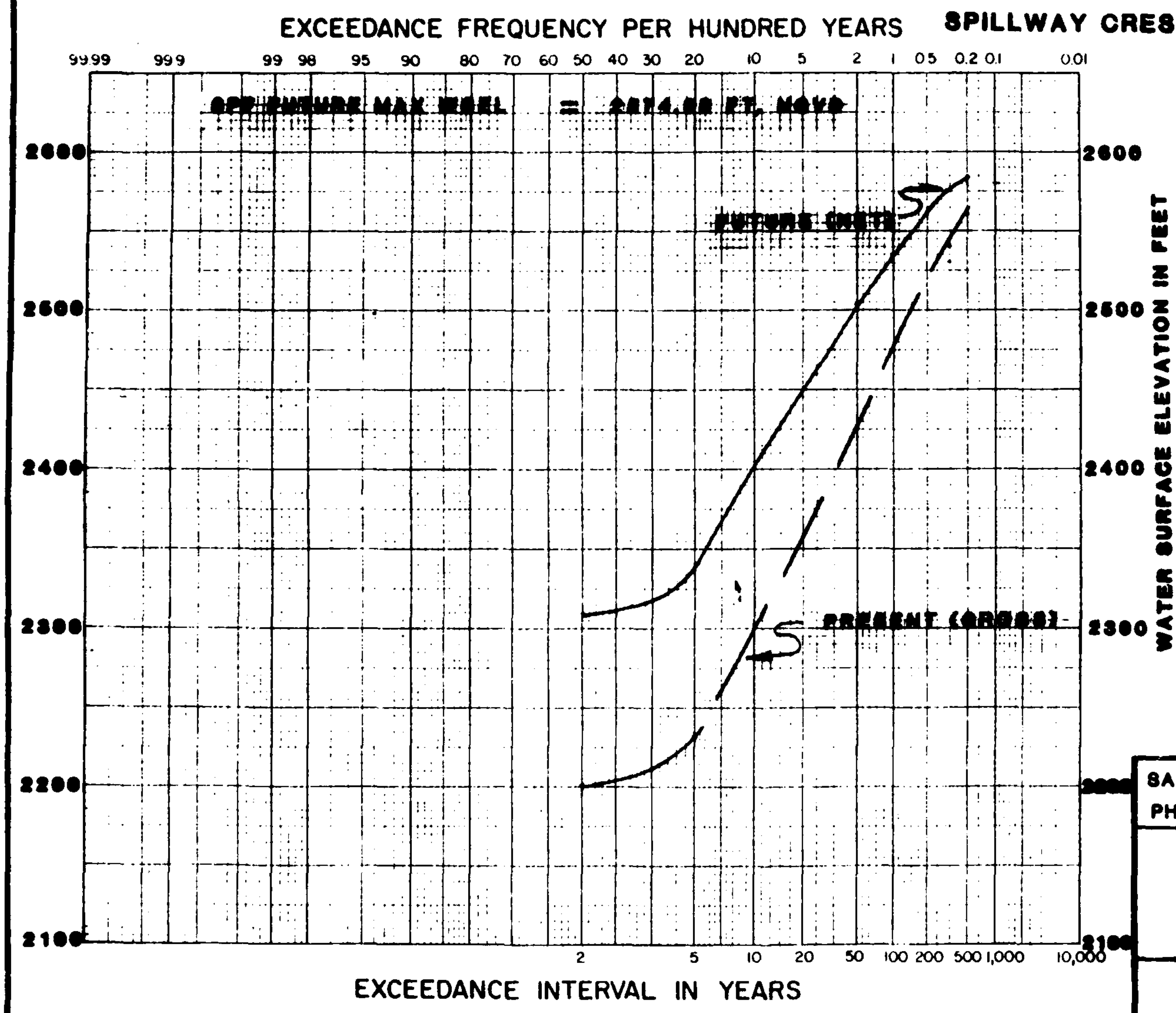
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ELEVATION-DURATION-FREQUENCY CURVES

SEVEN OAKS DAM
FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-29



SPILLWAY CREST ELEVATION AT 2580 FT.

TOP OF DAM 2610 FEET

GROSS STORAGE AT SPILLWAY CREST = 145,000 A.F.

NET STORAGE AT SPILLWAY CREST = 113,000 A.F.

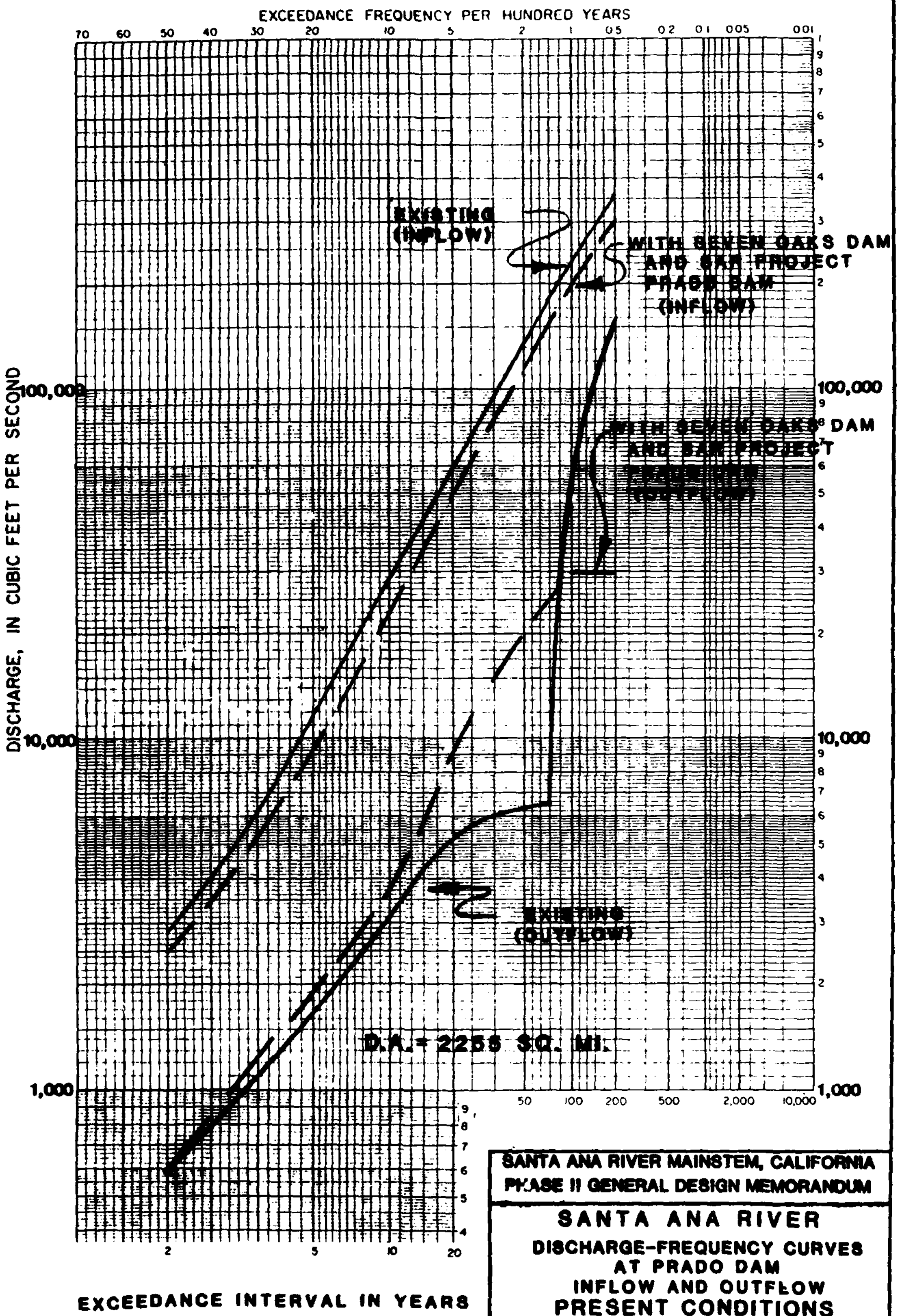
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SEVEN OAKS DAM

FILLING-FREQUENCY CURVE

PRESENT AND FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



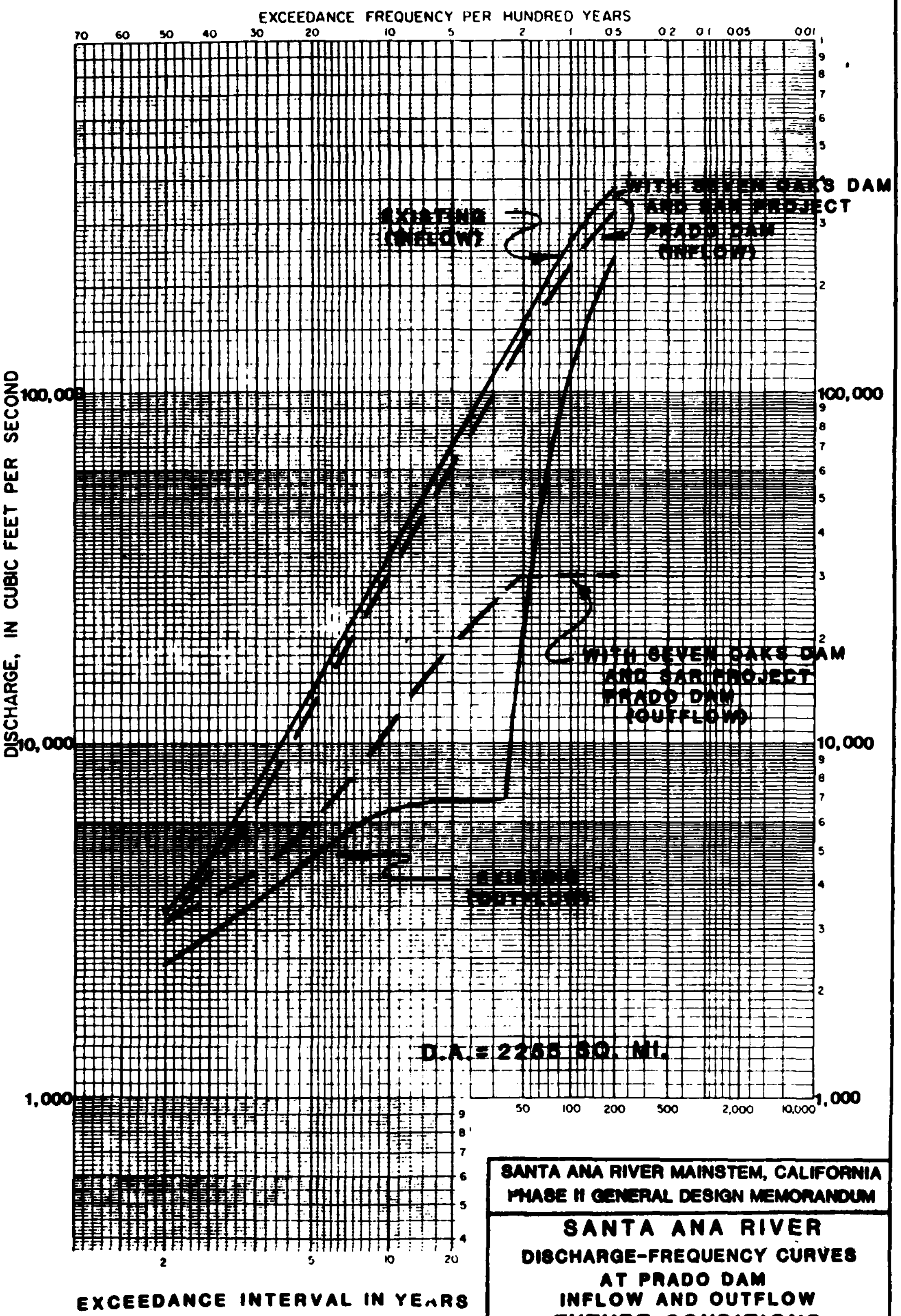
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER

DISCHARGE-FREQUENCY CURVES AT PRADO DAM INFLOW AND OUTFLOW

PRESENT CONDITIONS

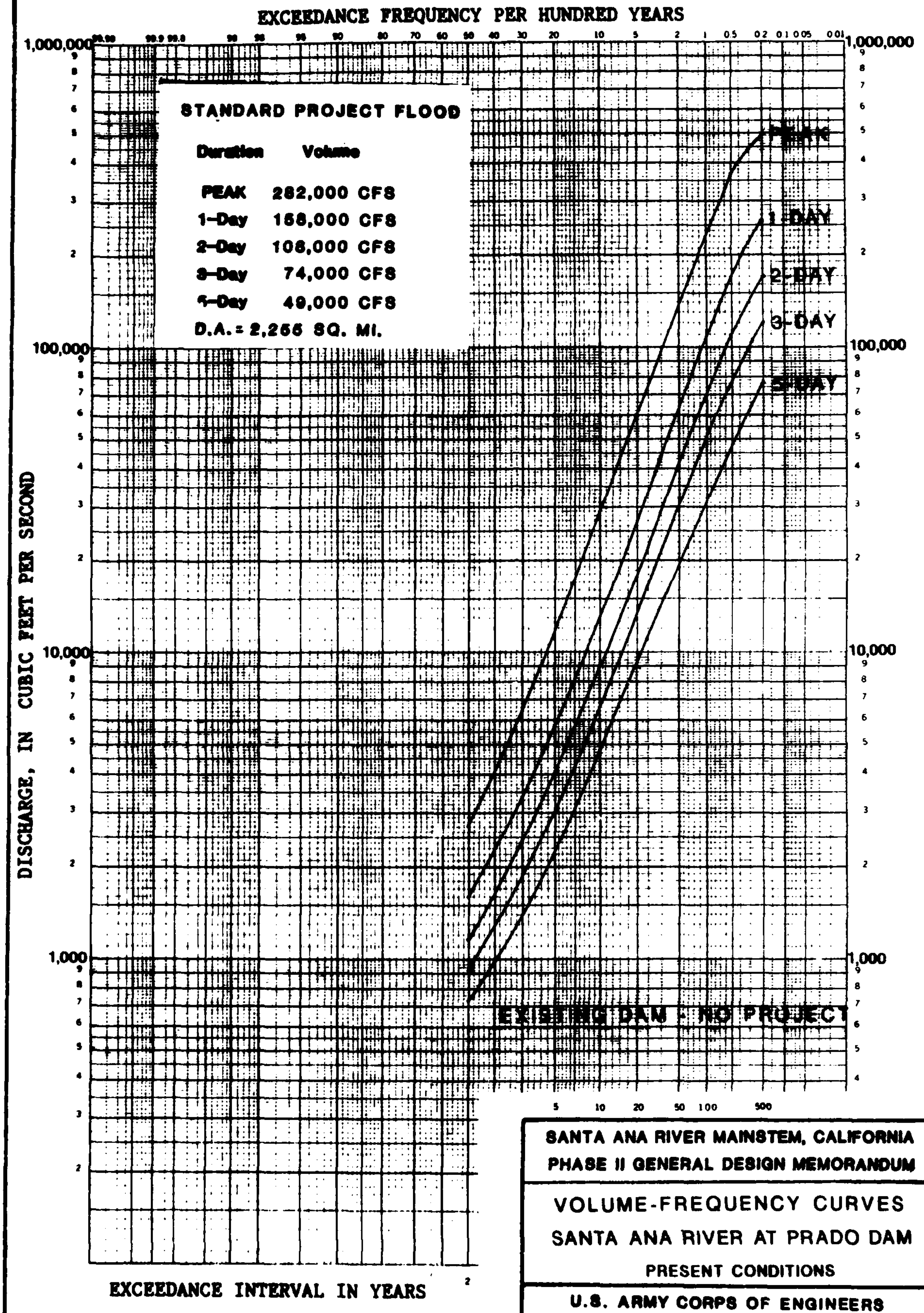
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT PRADO DAM
INFLOW AND OUTFLOW
FUTURE CONDITIONS

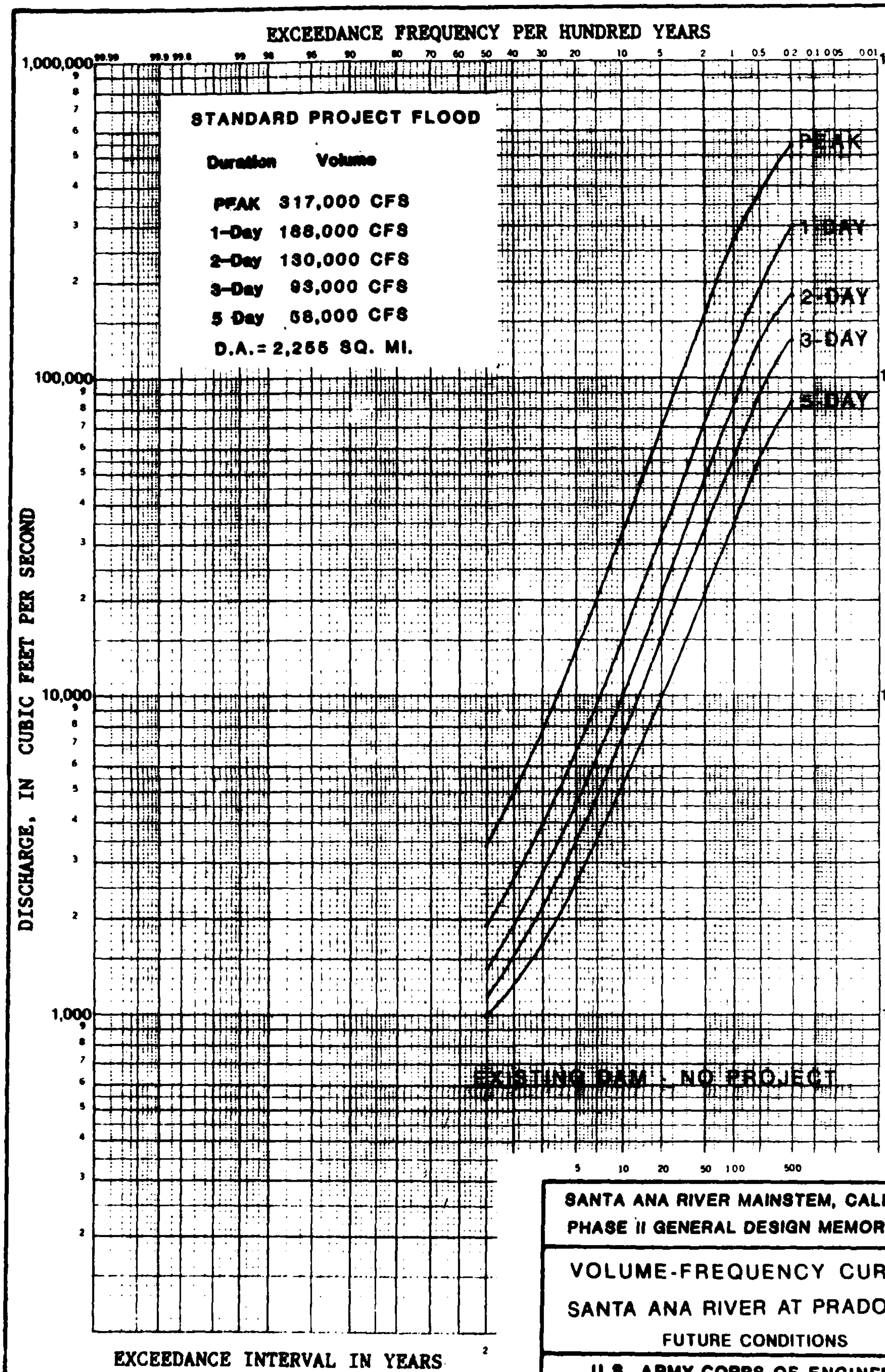
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

VOLUME-FREQUENCY CURVES
SANTA ANA RIVER AT PRADO DAM
PRESENT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

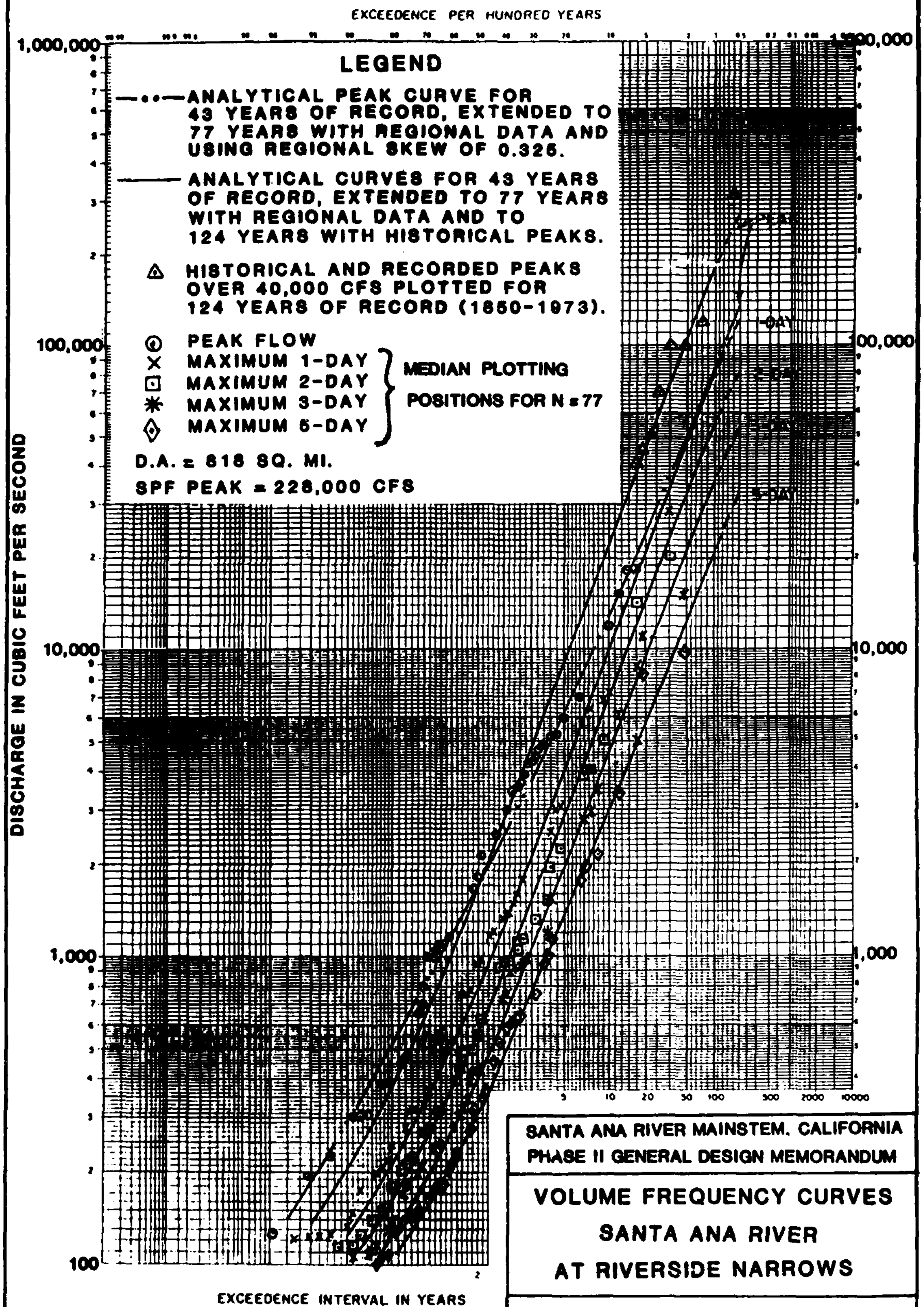


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

VOLUME-FREQUENCY CURVES
SANTA ANA RIVER AT PRADO DAM
FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

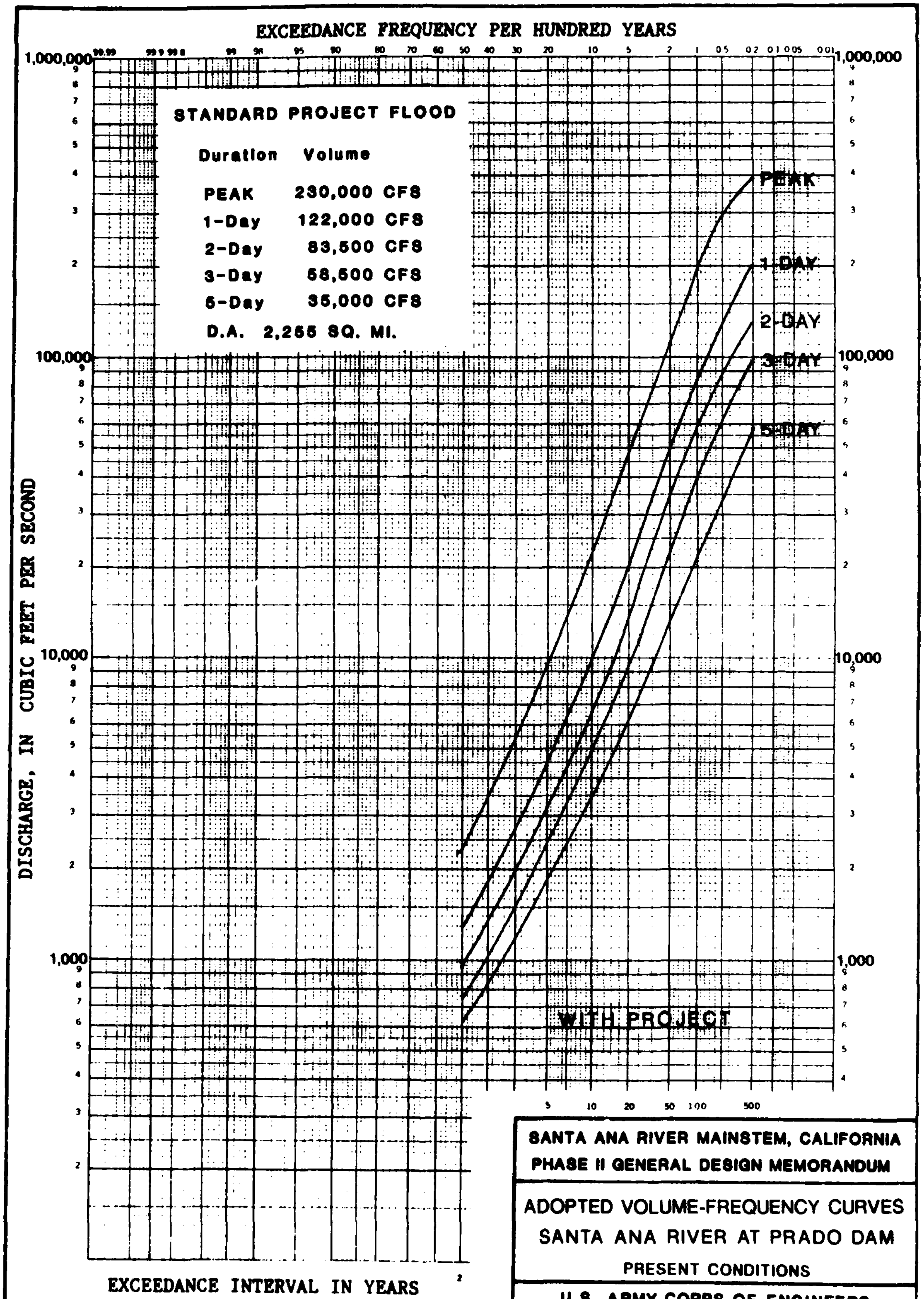
PLATE 7-34



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

VOLUME FREQUENCY CURVES
SANTA ANA RIVER
AT RIVERSIDE NARROWS

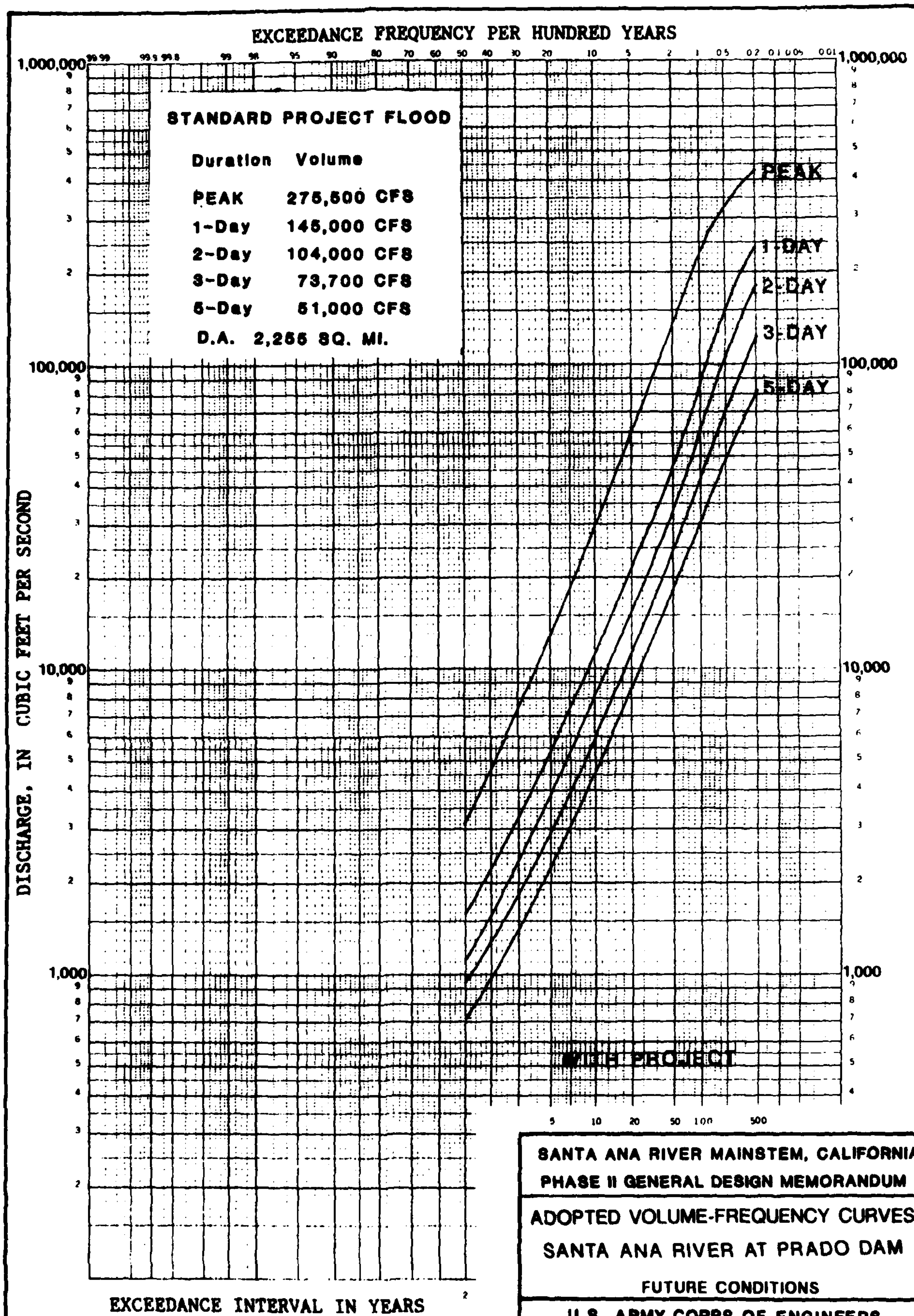
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ADOPTED VOLUME-FREQUENCY CURVES
SANTA ANA RIVER AT PRADO DAM
PRESENT CONDITIONS

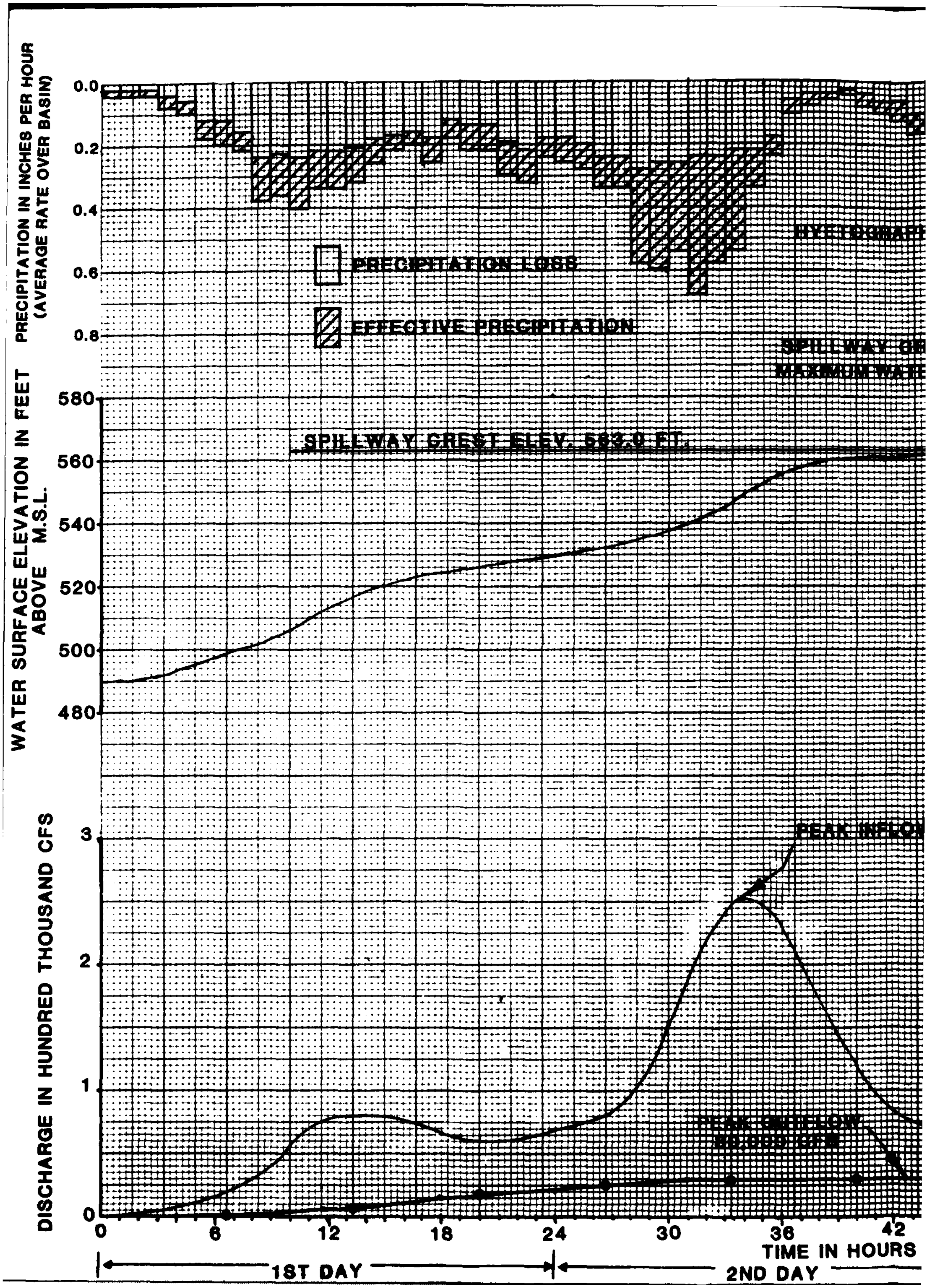
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



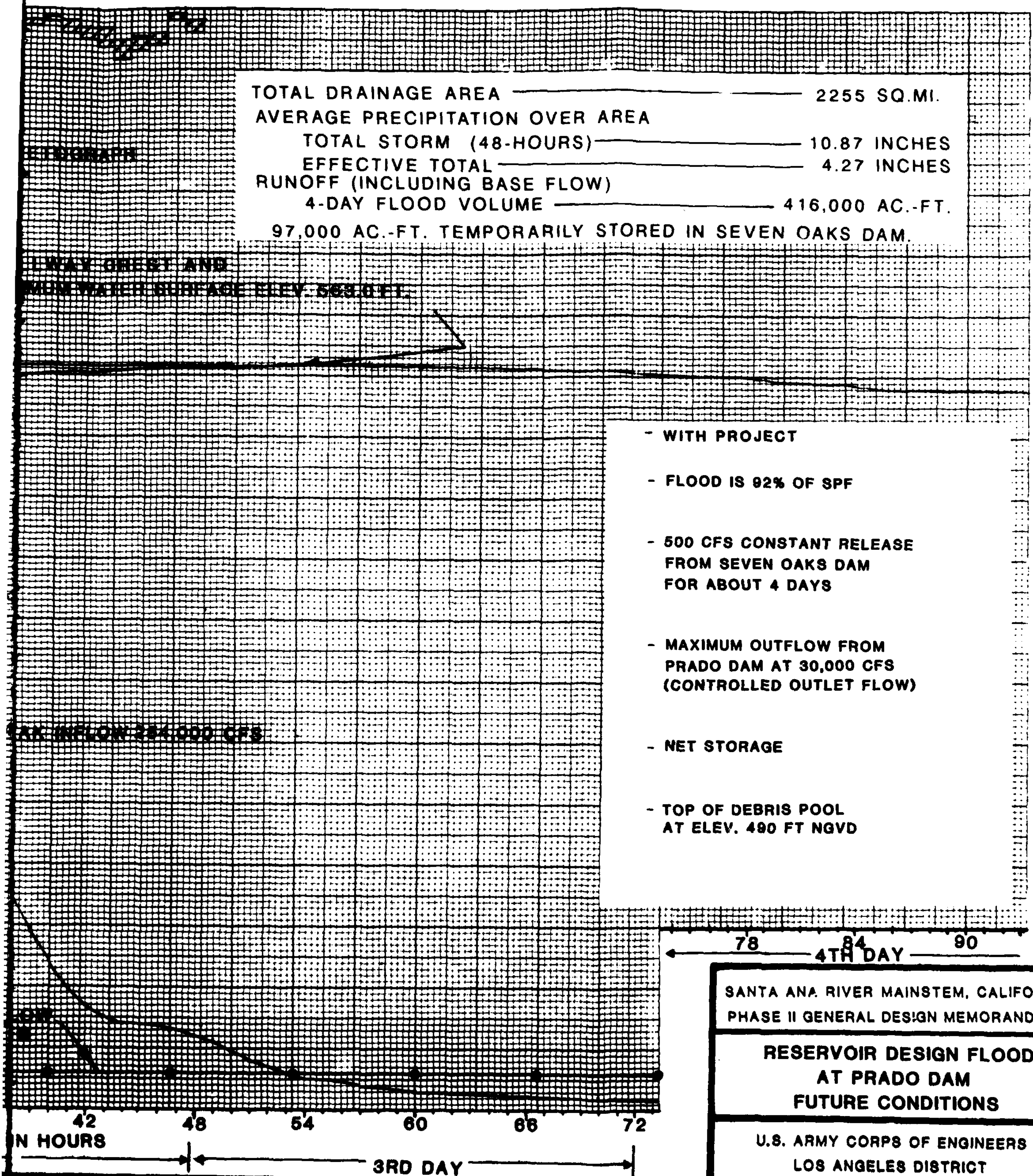
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ADOPTED VOLUME-FREQUENCY CURVES
SANTA ANA RIVER AT PRADO DAM
FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



PRECIPITATION IN INCHES PER HOUR (AVERAGE RATE OVER BASIN)
0.0
0.2
0.4
0.6
0.8
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
WATER SURFACE ELEVATION IN FEET ABOVE M.S.L.
580
560
540
520
500
480
SPILLWAY CREST ELEV. 563.0 FT.
DISCHARGE IN HUNDRED THOUSAND CFS
3
2
1
0
0
6
12
18
24
30
36
42
TIME IN HOURS
1ST DAY
2ND DAY

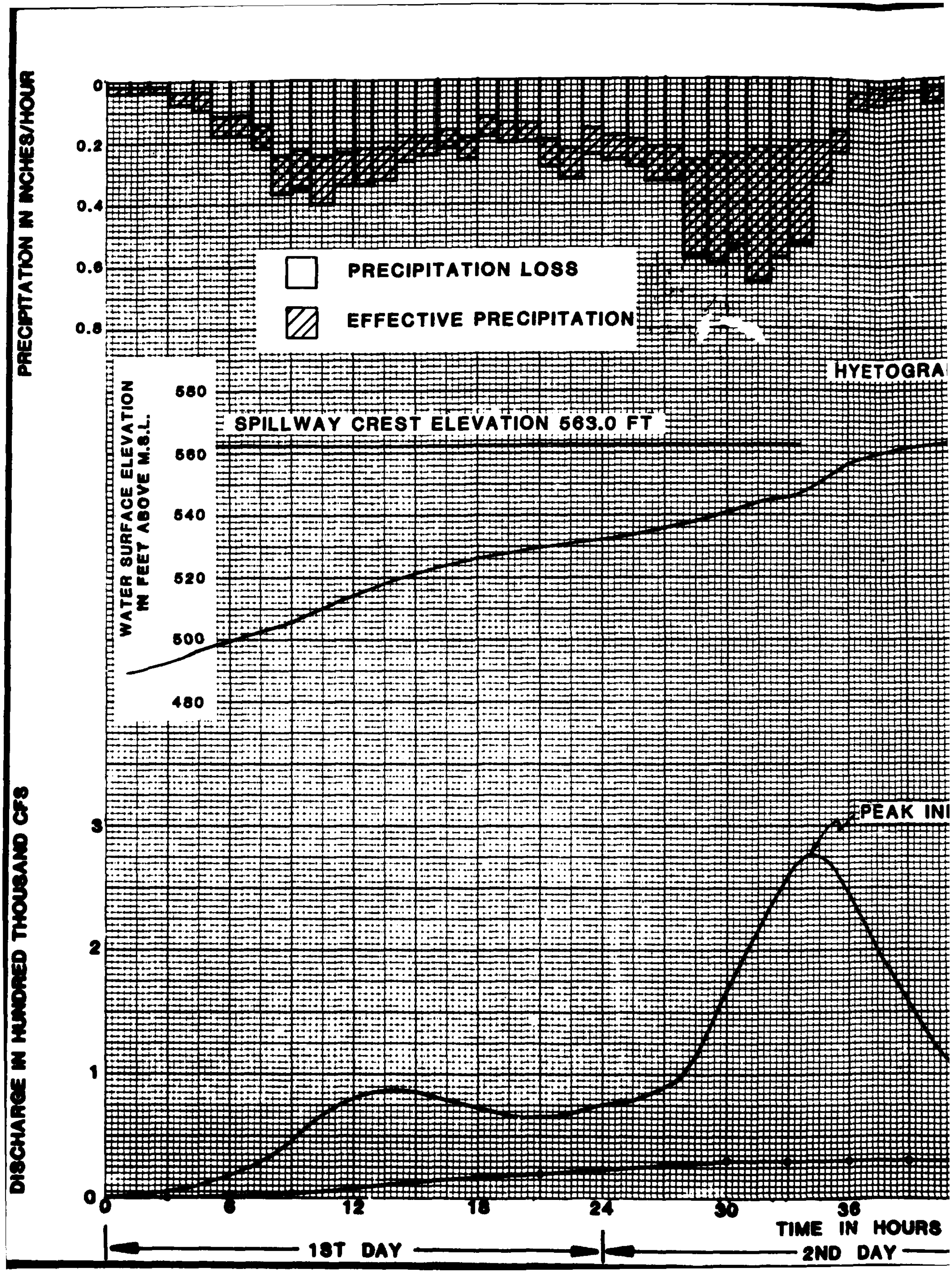


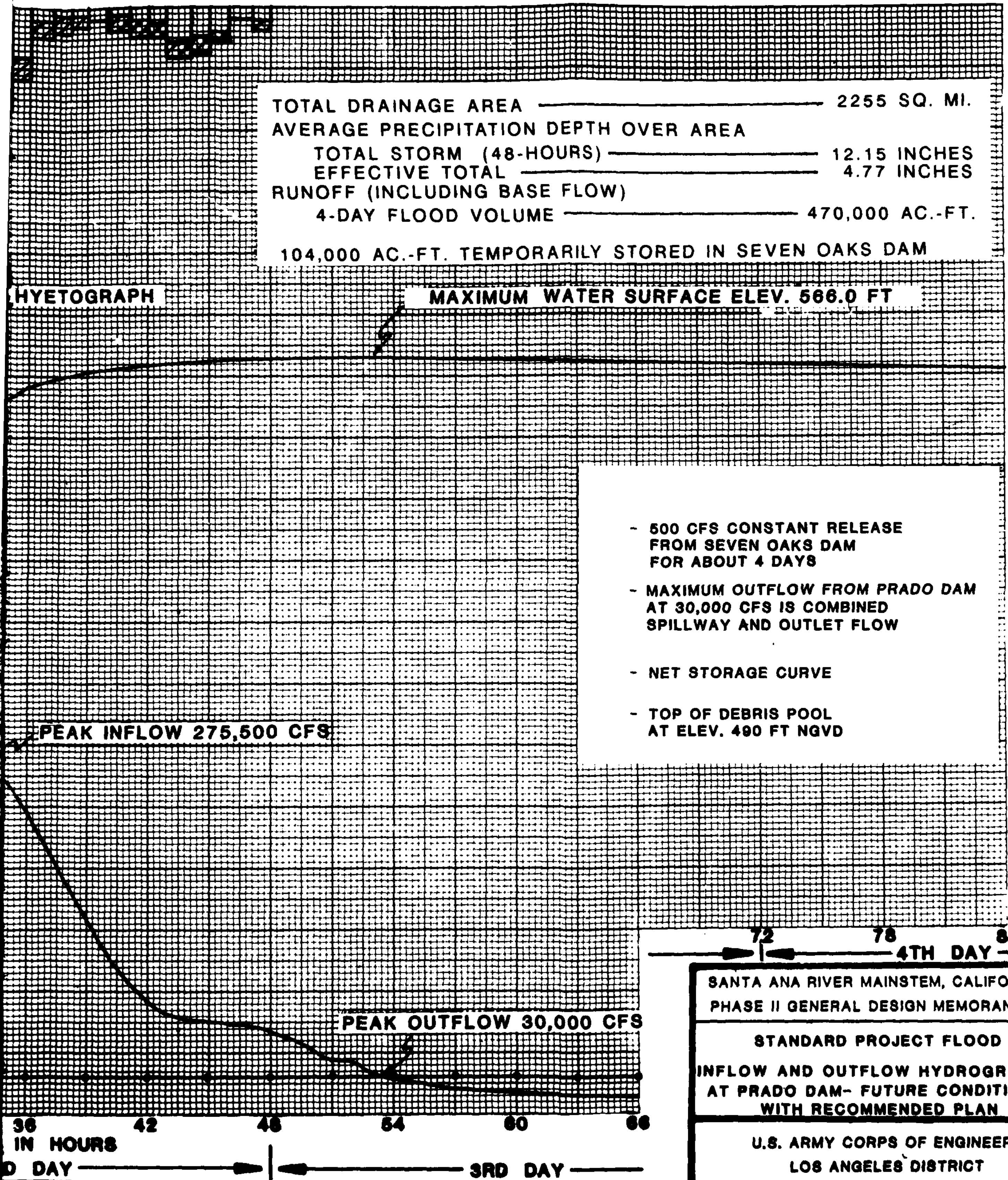
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

RESERVOIR DESIGN FLOOD AT PRADO DAM FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

2


PRECIPITATION IN INCHES/HOUR
0
0.2
0.4
0.6
0.8
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
HYETOGRA
WATER SURFACE ELEVATION IN FEET ABOVE M.S.L.
580
560
540
520
500
480
SPILLWAY CREST ELEVATION 563.0 FT
DISCHARGE IN HUNDRED THOUSAND CFS
3
2
1
0
PEAK INI
0
6
12
18
24
30
36
TIME IN HOURS
1ST DAY
2ND DAY



SANTA ANA RIVER MAINSTEM, CALIFORNIA

PHASE II GENERAL DESIGN MEMORANDUM

STANDARD PROJECT FLOOD

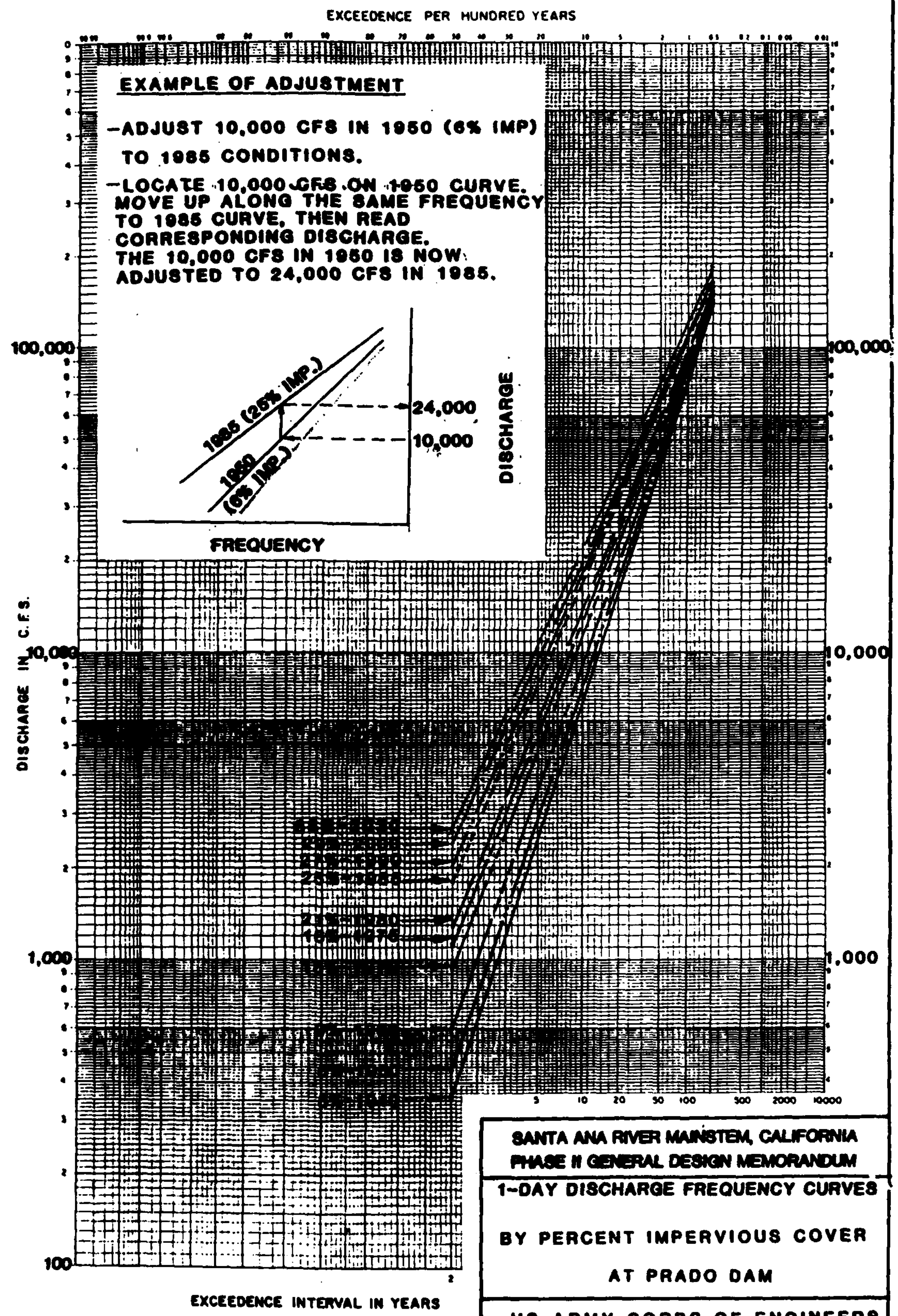
INFLOW AND OUTFLOW HYDROGRAPHS AT PRADO DAM- FUTURE CONDITIONS WITH RECOMMENDED PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-39

1

2



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

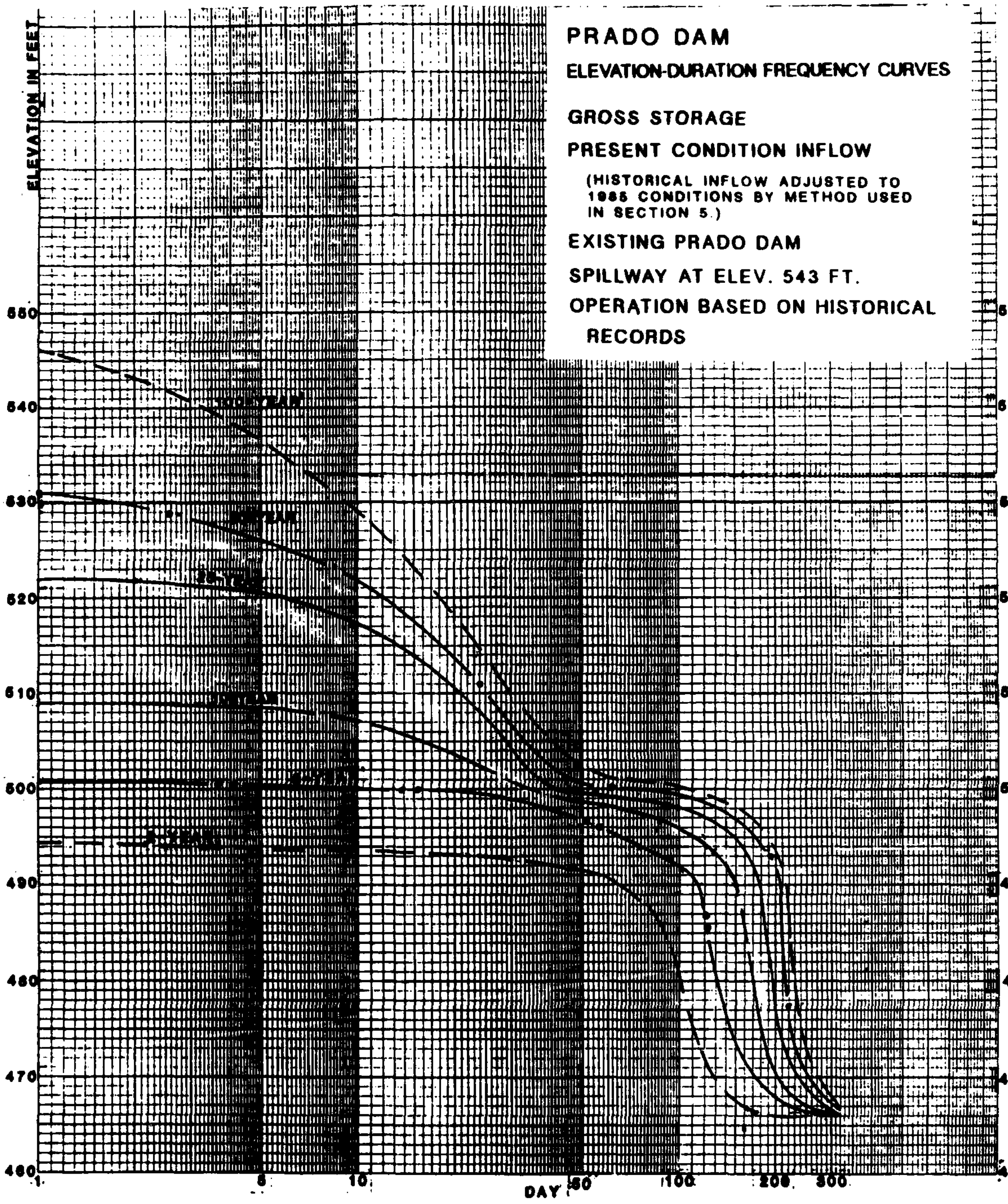
1-DAY DISCHARGE FREQUENCY CURVES

BY PERCENT IMPERVIOUS COVER

AT PRADO DAM

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

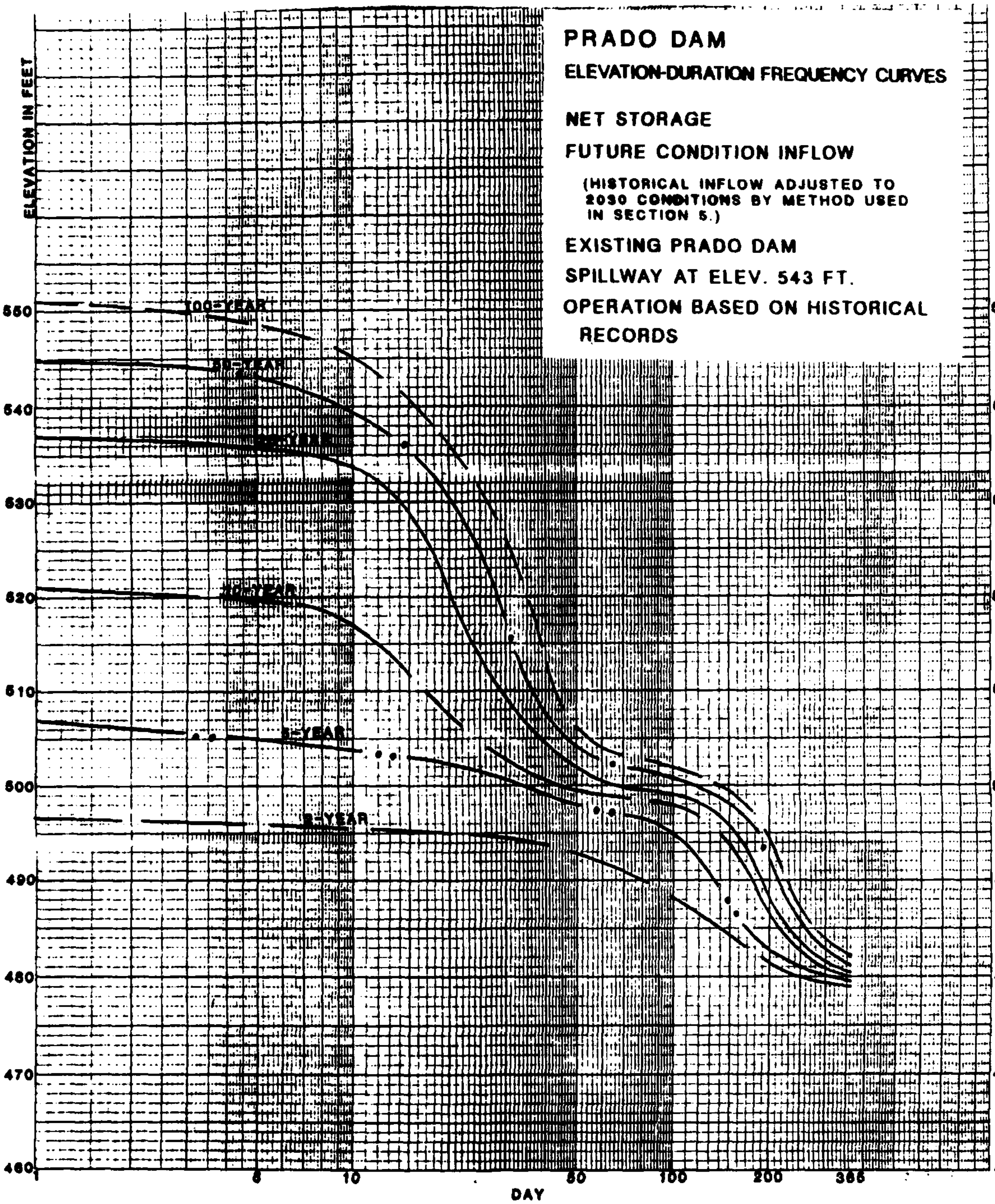
PLATE 7-40



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ELEVATION-DURATION-FREQUENCY CURVES
PRADO DAM
PRESENT CONDITIONS
EXISTING PRADO DAM

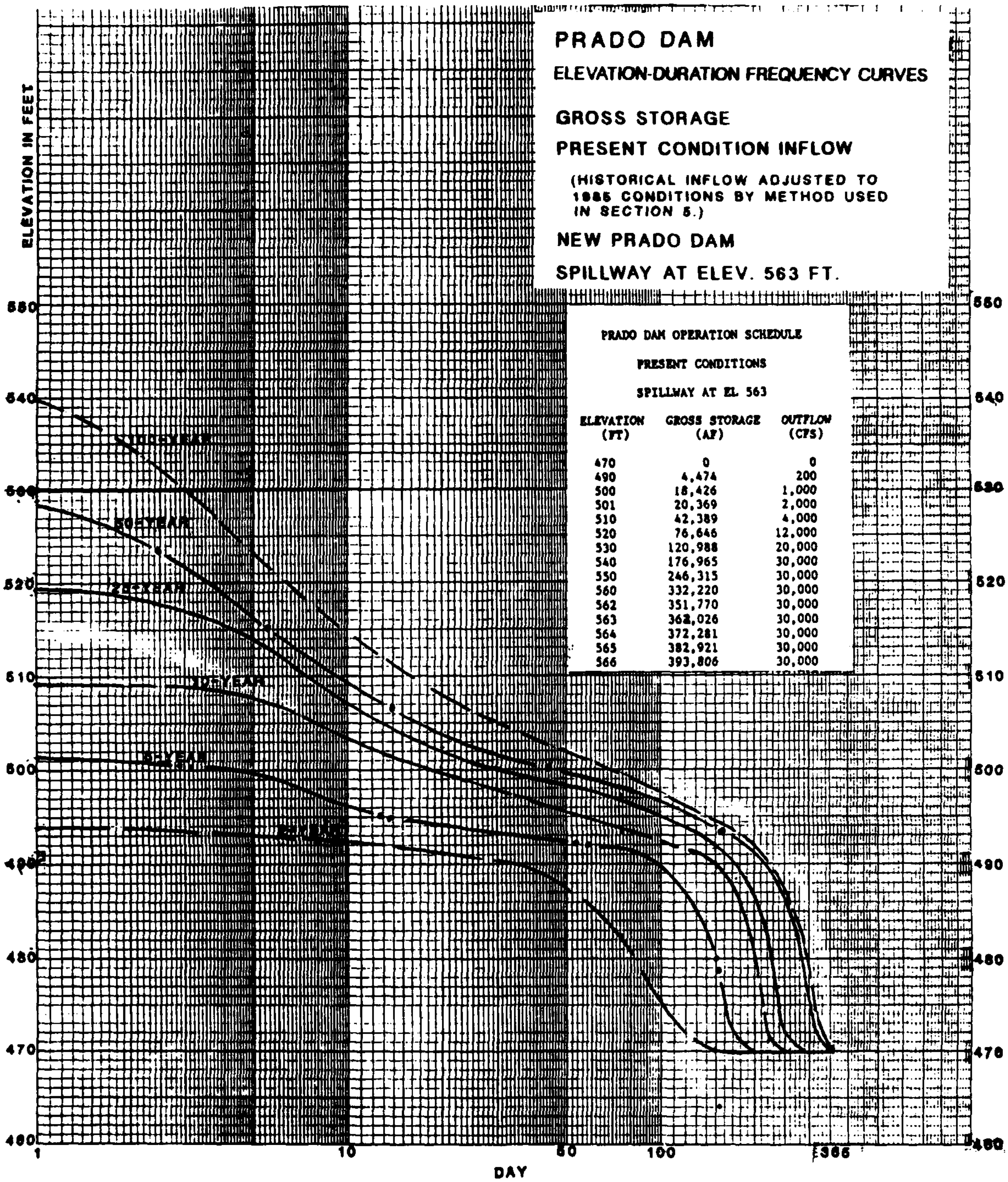
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ELEVATION-DURATION-FREQUENCY CURVES
PRADO DAM
FUTURE CONDITIONS
EXISTING PRADO DAM

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



PRADO DAM OPERATION SCHEDULE

PRESENT CONDITIONS

SPILLWAY AT EL 563

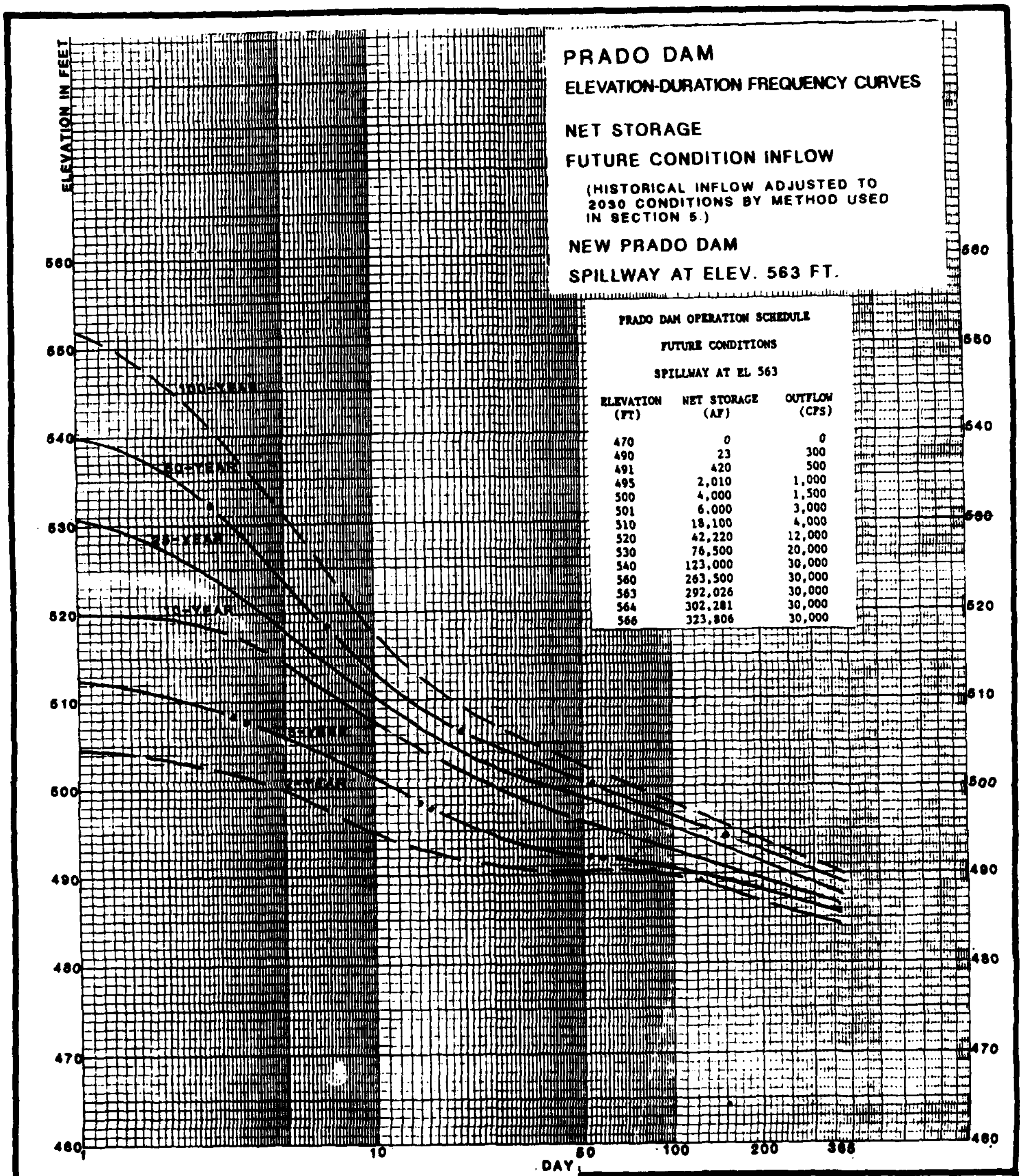
ELEVATION (FT)	GROSS STORAGE (AF)	OUTFLOW (CFS)
470	0	0
490	4,474	200
500	18,426	1,000
501	20,369	2,000
510	42,389	4,000
520	76,646	12,000
530	120,988	20,000
540	176,965	30,000
550	246,315	30,000
560	332,220	30,000
562	351,770	30,000
563	362,026	30,000
564	372,281	30,000
565	382,921	30,000
566	393,806	30,000

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ELEVATION-DURATION-FREQUENCY CURVES
PRADO DAM
PRESENT CONDITIONS
SANTA ANA RIVER PROJECT PRADO DAM

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-43



PRADO DAM

ELEVATION-DURATION FREQUENCY CURVES

NET STORAGE

FUTURE CONDITION INFLOW

(HISTORICAL INFLOW ADJUSTED TO 2030 CONDITIONS BY METHOD USED IN SECTION 5.)

NEW PRADO DAM

SPILLWAY AT ELEV. 563 FT.

PRADO DAM OPERATION SCHEDULE

FUTURE CONDITIONS

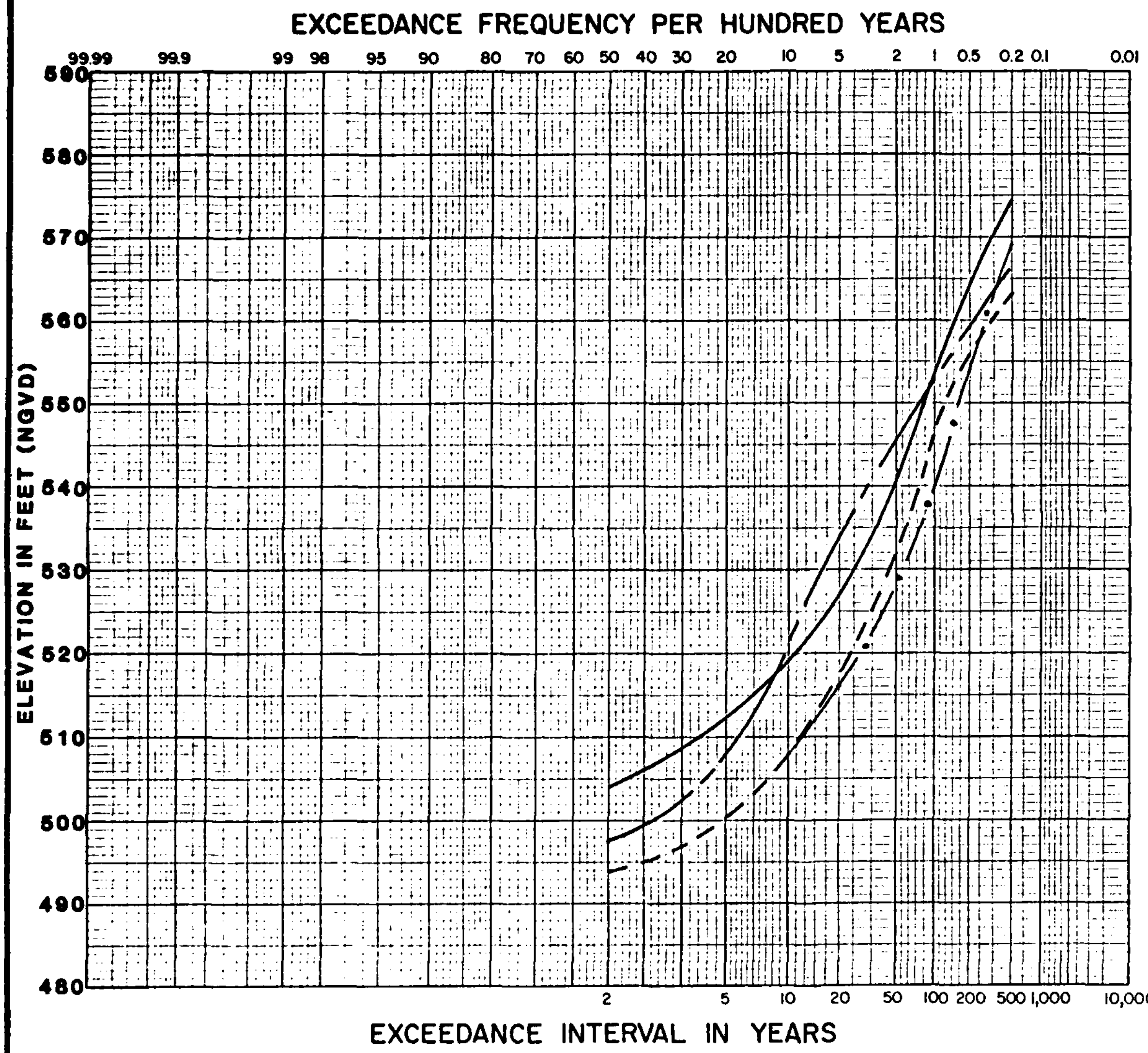
SPILLWAY AT EL 563

ELEVATION (FT)	NET STORAGE (AF)	OUTFLOW (CFS)
470	0	0
490	23	300
491	420	500
495	2,010	1,000
500	4,000	1,500
501	6.000	3,000
510	18,100	4,000
520	42,220	12,000
530	76,500	20,000
540	123,000	30,000
560	263,500	30,000
563	292,026	30,000
564	302,281	30,000
566	323,806	30,000

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

ELEVATION-DURATION-FREQUENCY CURVES
PRADO DAM
FUTURE CONDITIONS
SANTA ANA RIVER PROJECT PRADO DAM

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



PRESENT CONDITIONS
HISTORICAL OPERATION
GROSS STORAGE
EXISTING PRADO DAM
-SPILLWAY AT 543

PRESENT CONDITIONS
PRESENT YEAR OPERATION
GROSS STORAGE
NEW PRADO DAM
-SPILLWAY AT 563

FUTURE CONDITIONS
FUTURE OPERATION
NET STORAGE
NEW PRADO DAM
-SPILLWAY AT 563

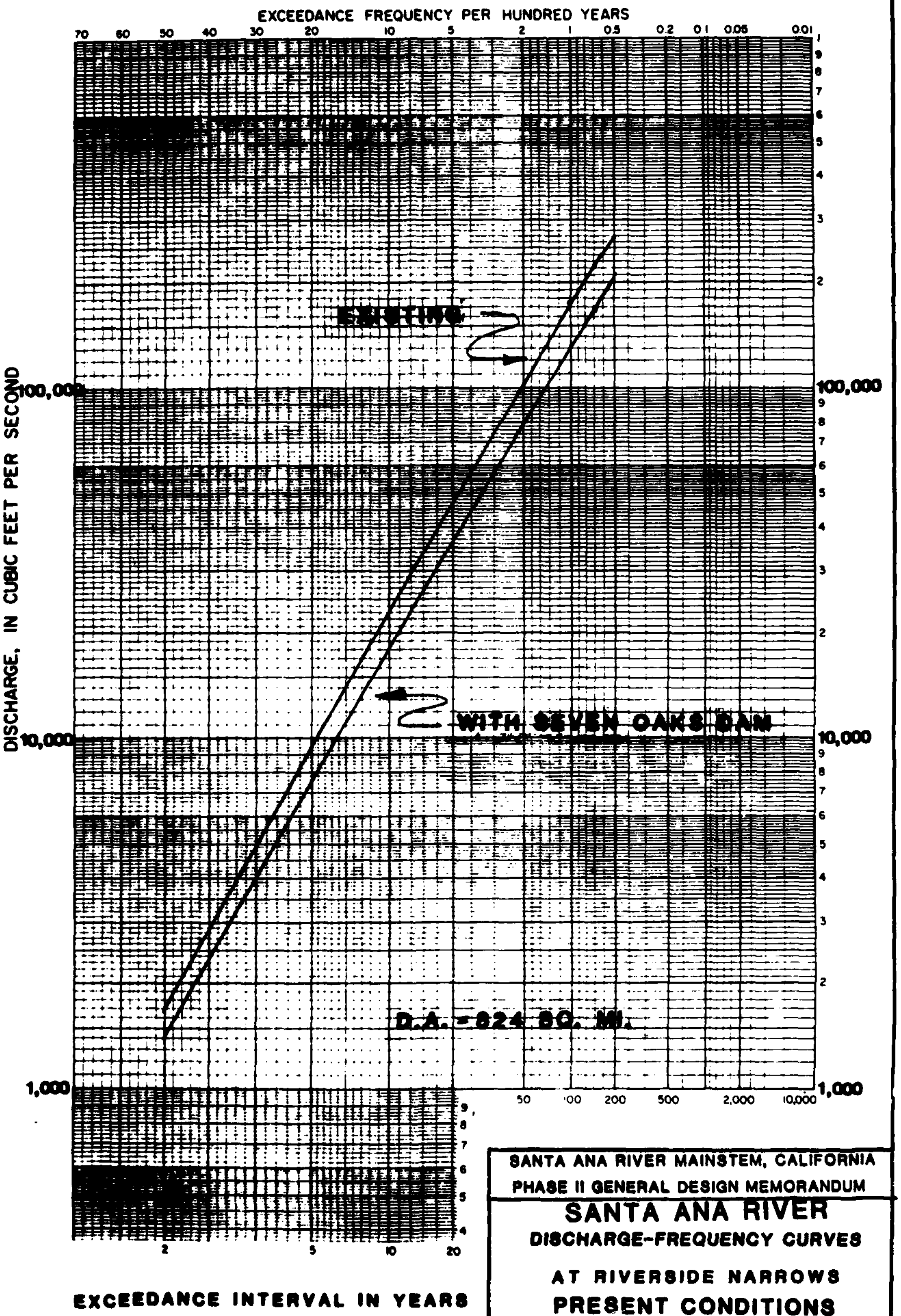
FUTURE CONDITIONS
HISTORICAL OPERATION
NET STORAGE
EXISTING PRADO DAM
-SPILLWAY AT 543

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PRADO DAM
FILLING-FREQUENCY CURVES
PRESENT AND FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

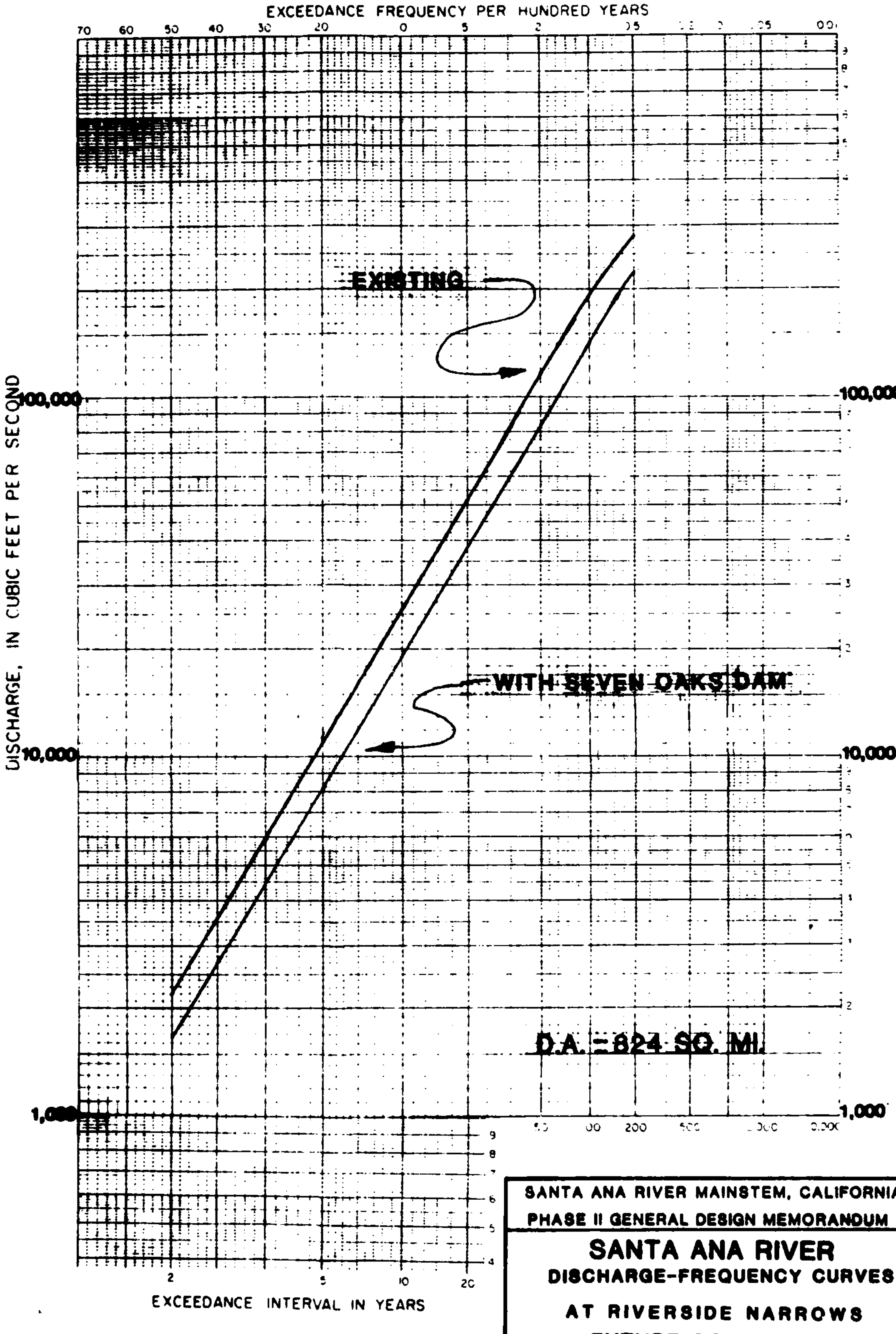
PLATE 7-45
REVISED



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT RIVERSIDE NARROWS
PRESENT CONDITIONS

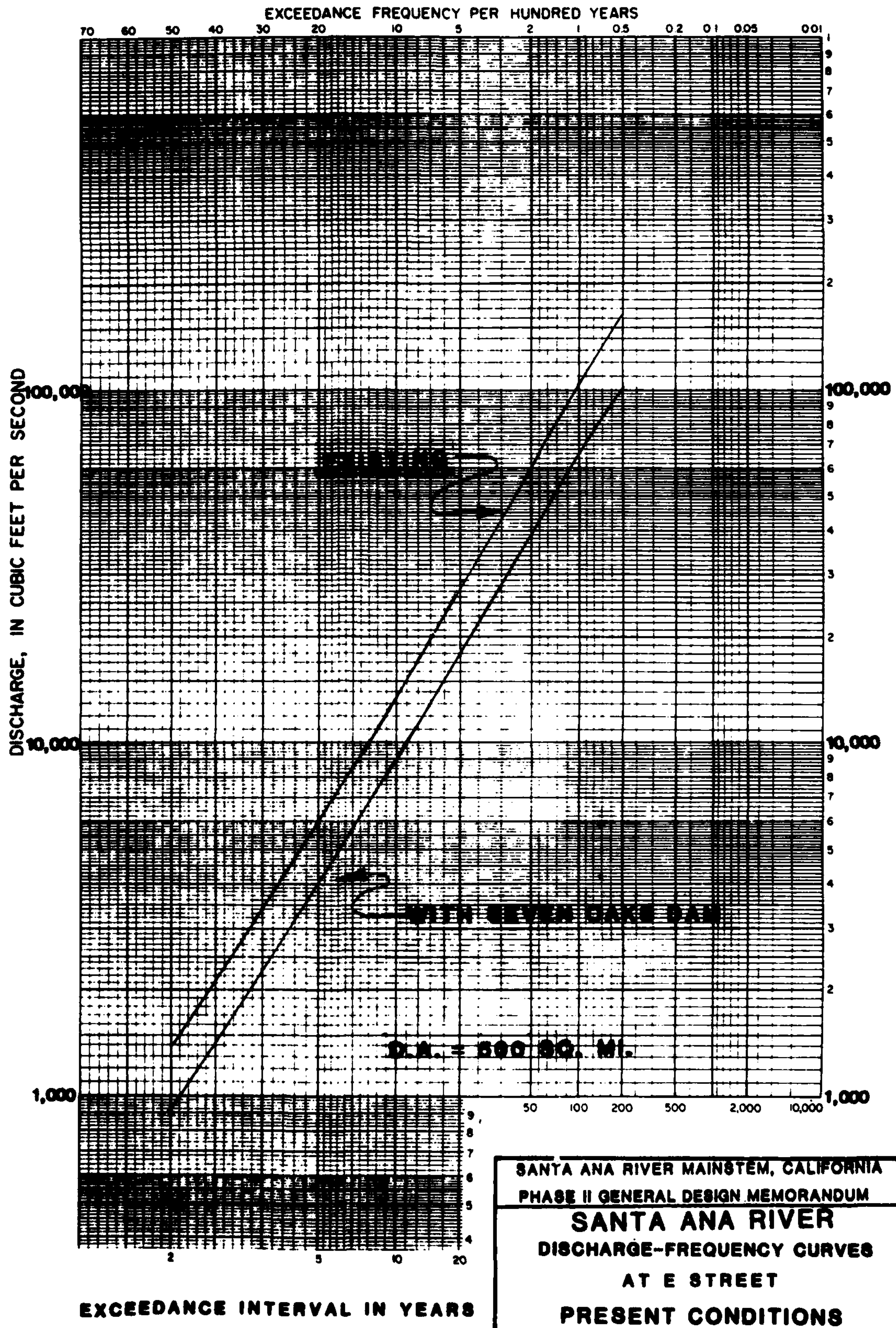
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT RIVERSIDE NARROWS
FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA

PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER

DISCHARGE-FREQUENCY CURVES

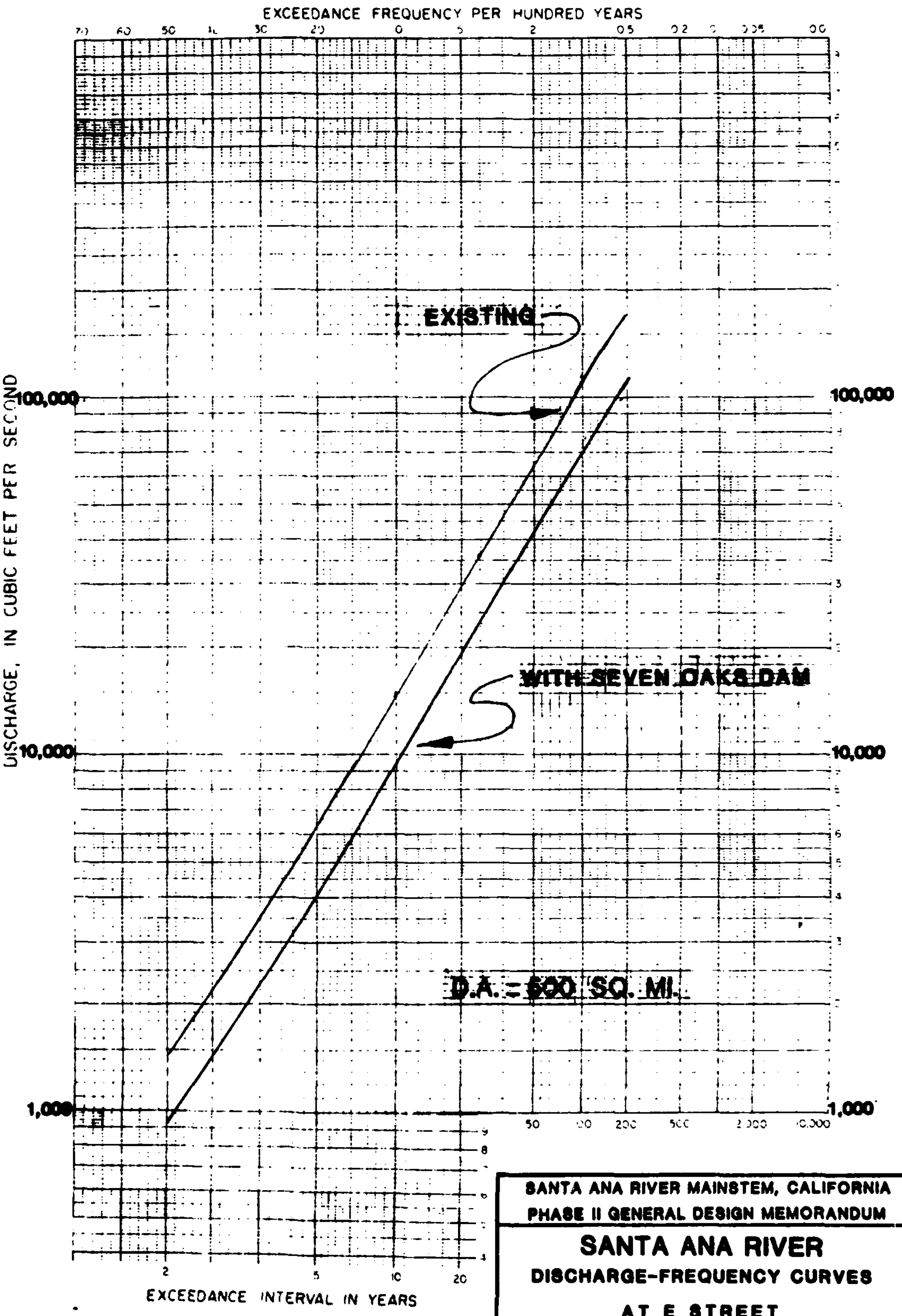
AT E STREET

PRESENT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS

LOS ANGELES DISTRICT

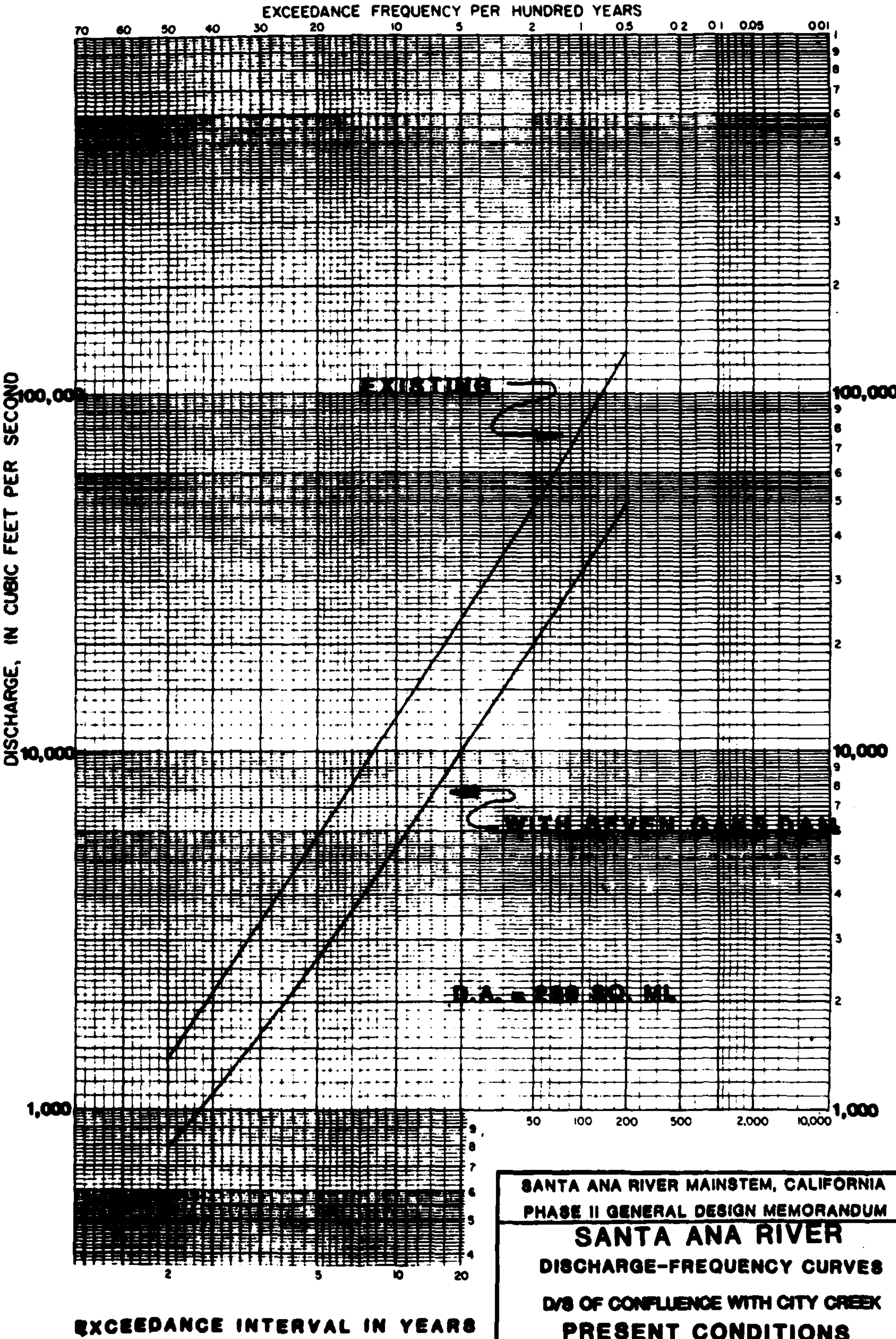
PLATE 7-48



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT E STREET
FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

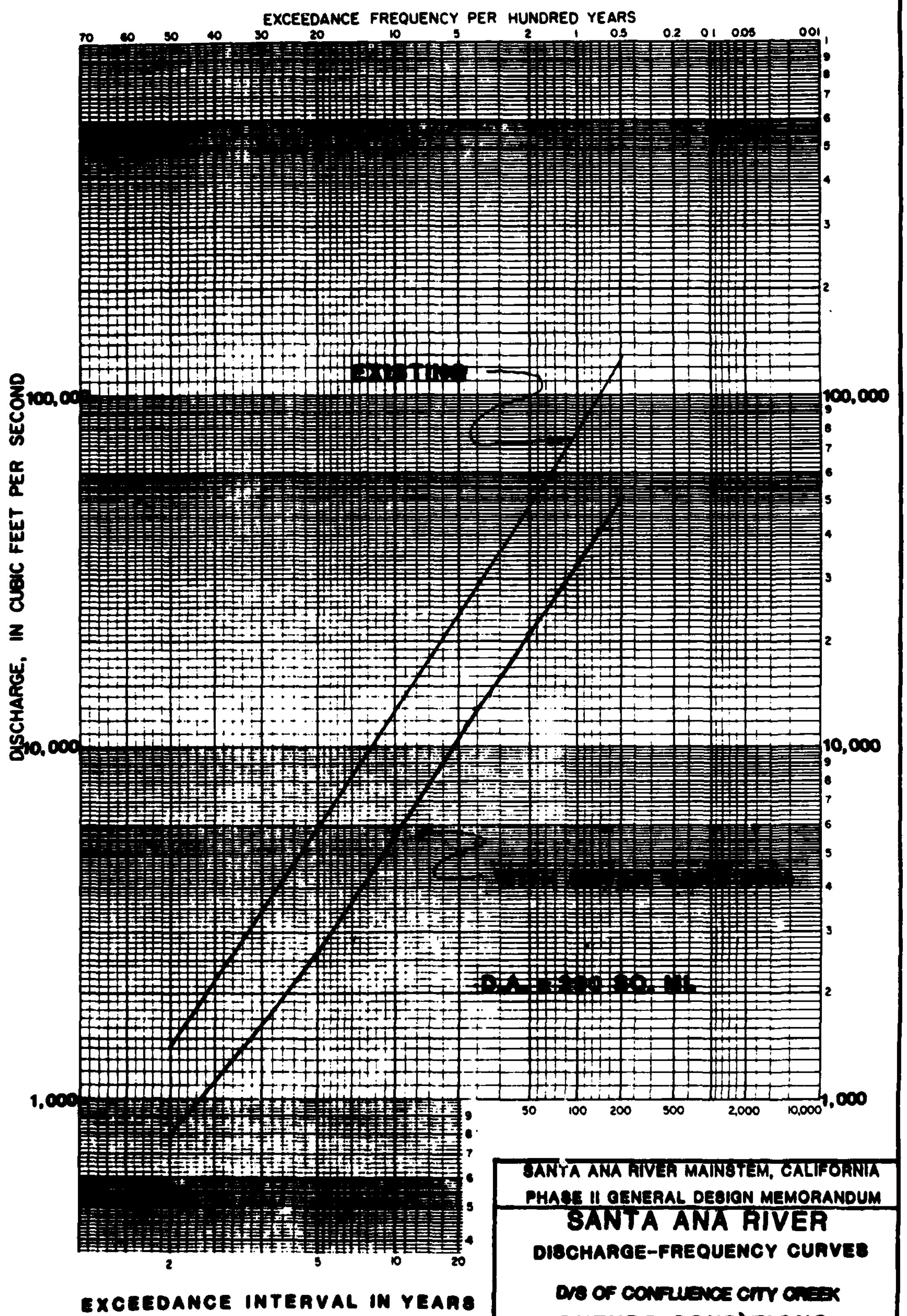
SANTA ANA RIVER

DISCHARGE-FREQUENCY CURVES

D/S OF CONFLUENCE WITH CITY CREEK

PRESENT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER

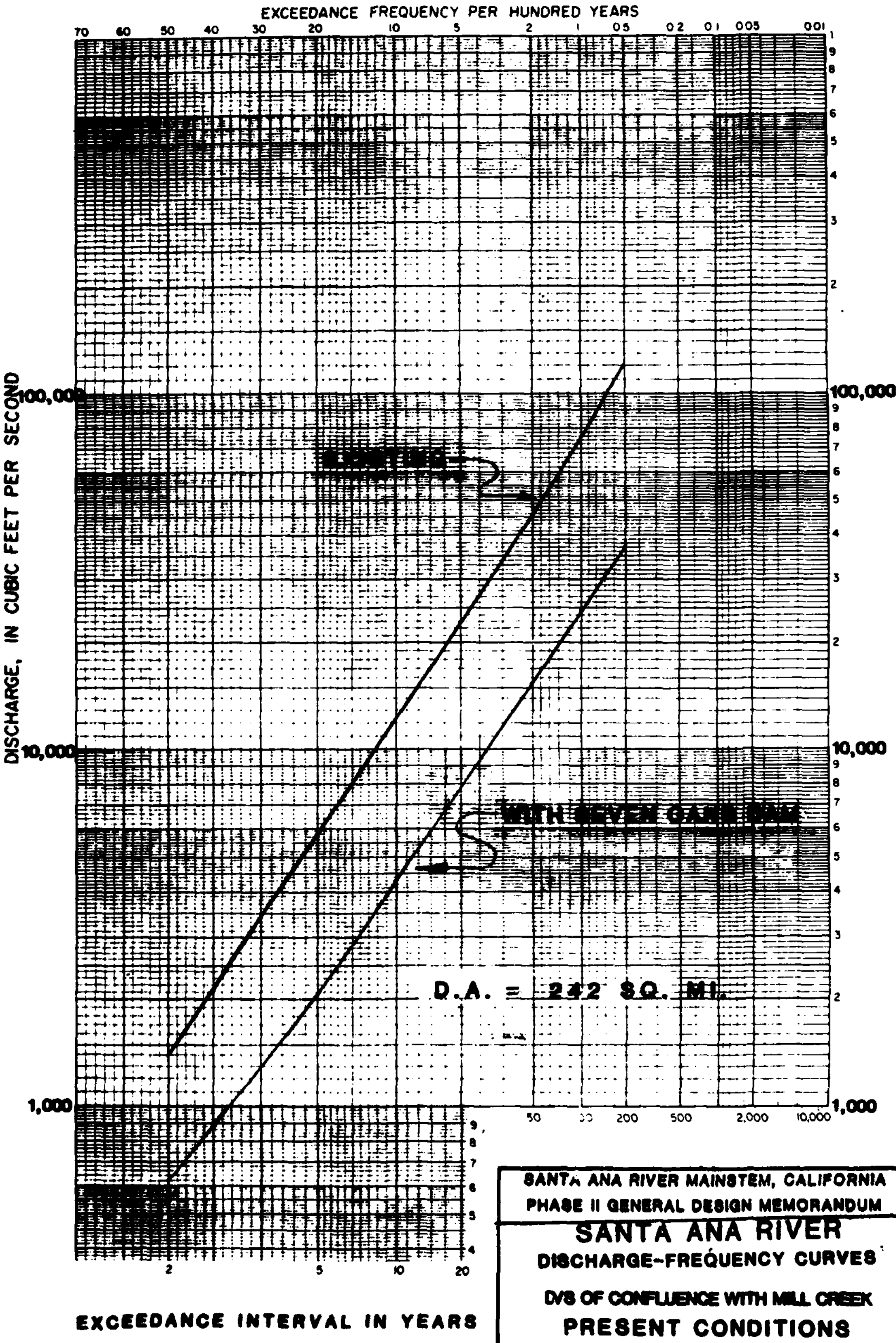
DISCHARGE-FREQUENCY CURVES

D/S OF CONFLUENCE CITY CREEK

FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-51



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER

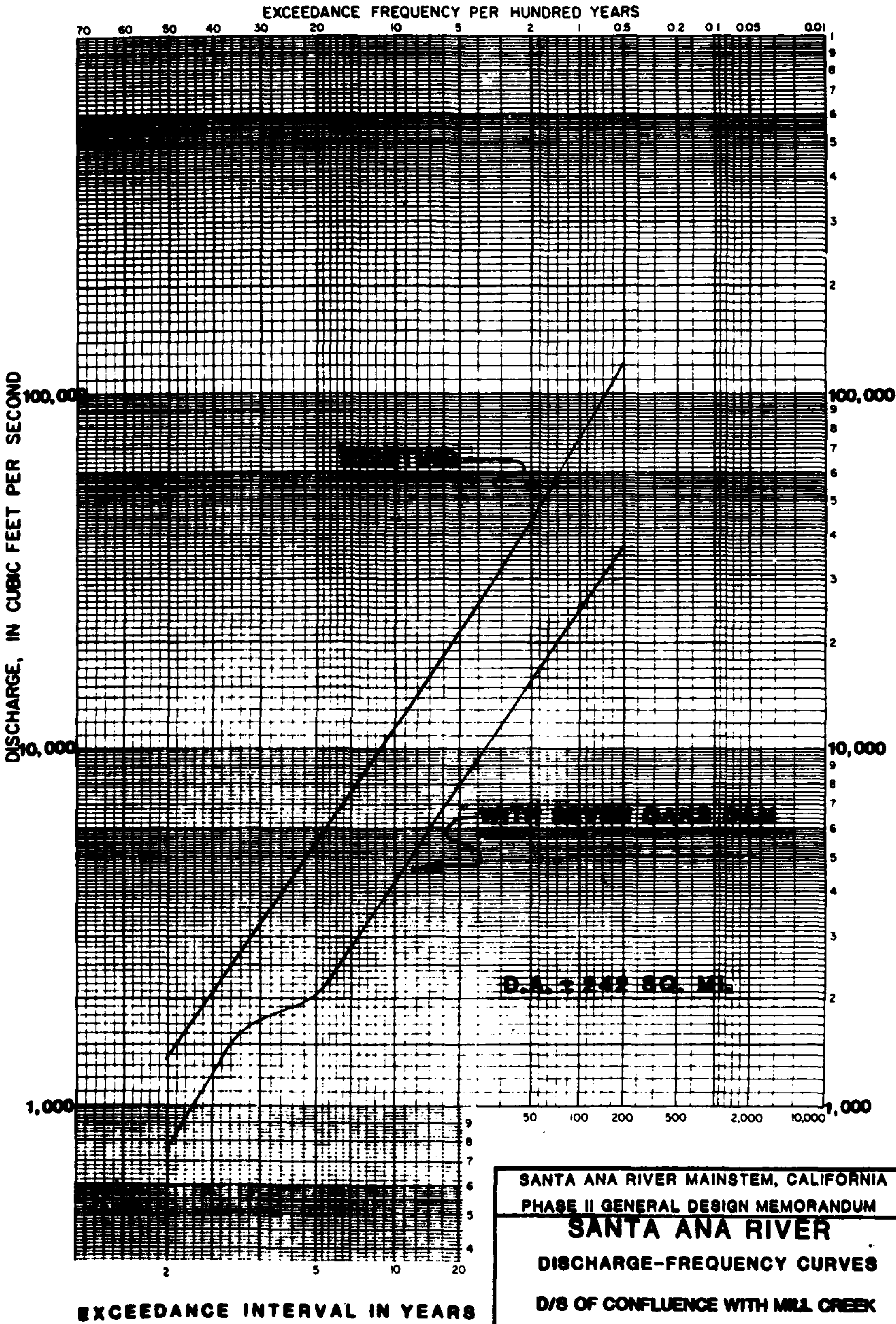
DISCHARGE-FREQUENCY CURVES

D/S OF CONFLUENCE WITH MILL CREEK

PRESENT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-52



SANTA ANA RIVER MAINSTEM, CALIFORNIA

PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER

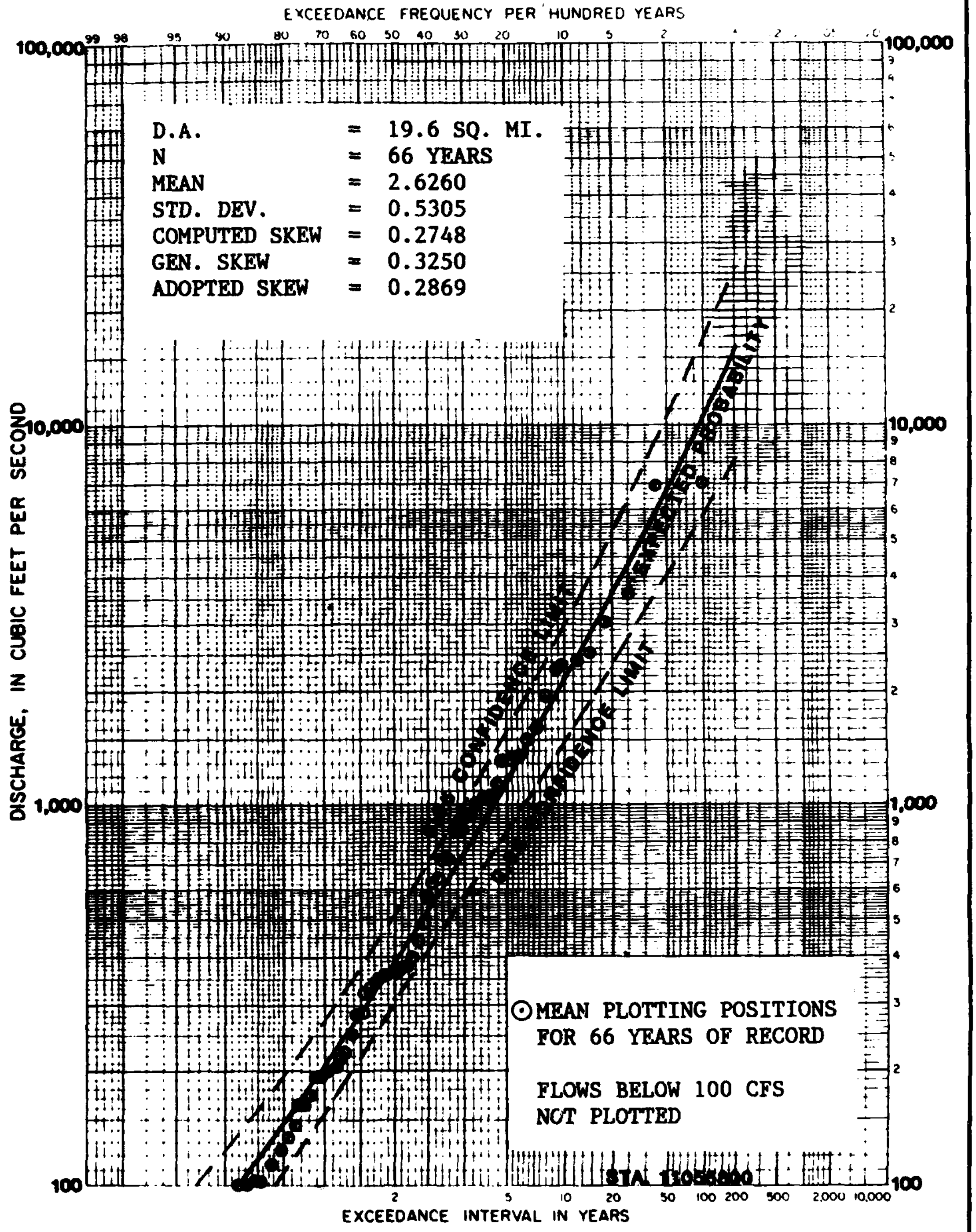
DISCHARGE-FREQUENCY CURVES

D/S OF CONFLUENCE WITH MILL CREEK

FUTURE CONDITIONS

U.S. ARMY CORPS OF ENGINEERS

LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

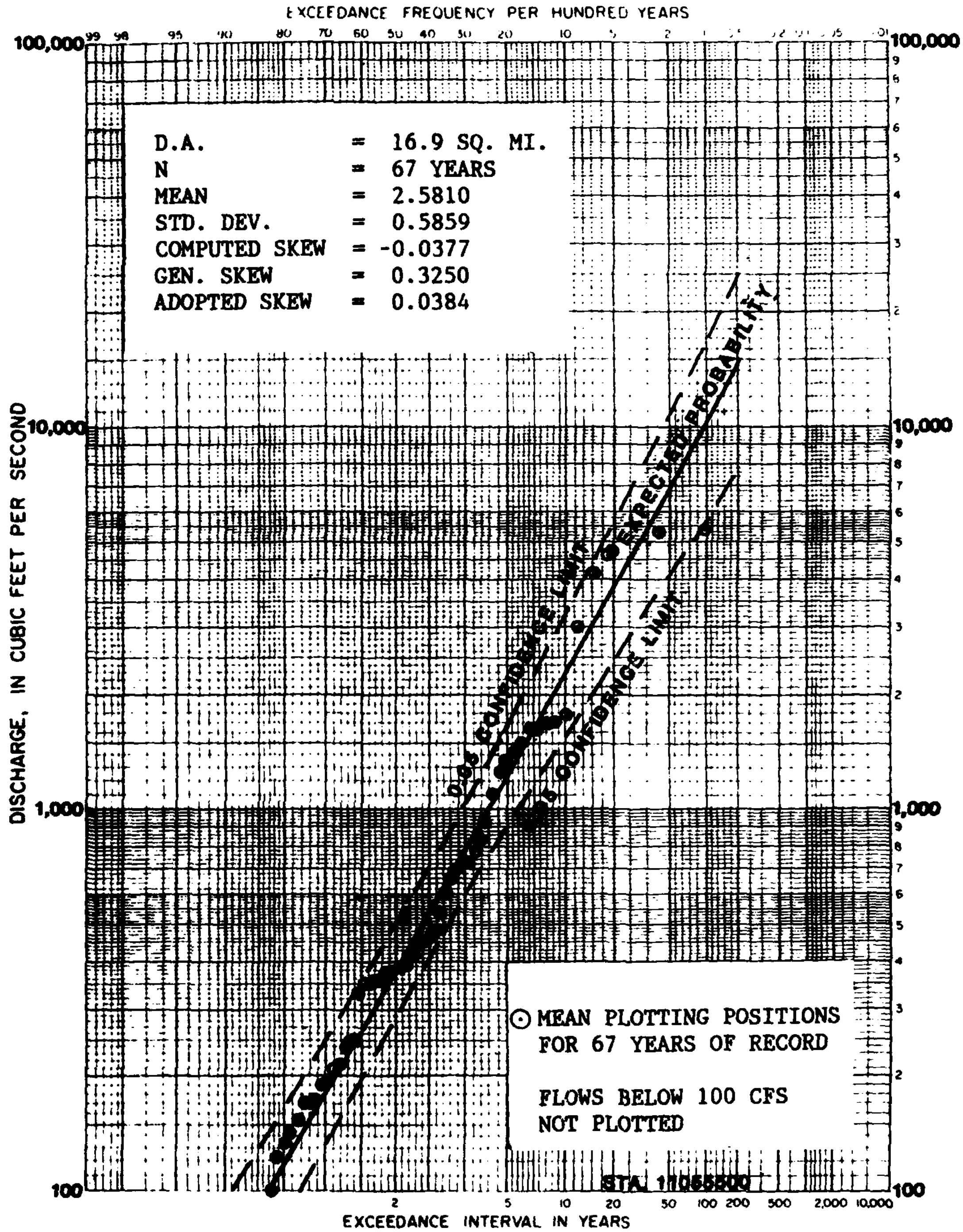
DISCHARGE-FREQUENCY CURVE

CITY CREEK

NEAR HIGHLAND, CA

PRESENT AND FUTURE CONDITIONS

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DISCHARGE-FREQUENCY CURVE

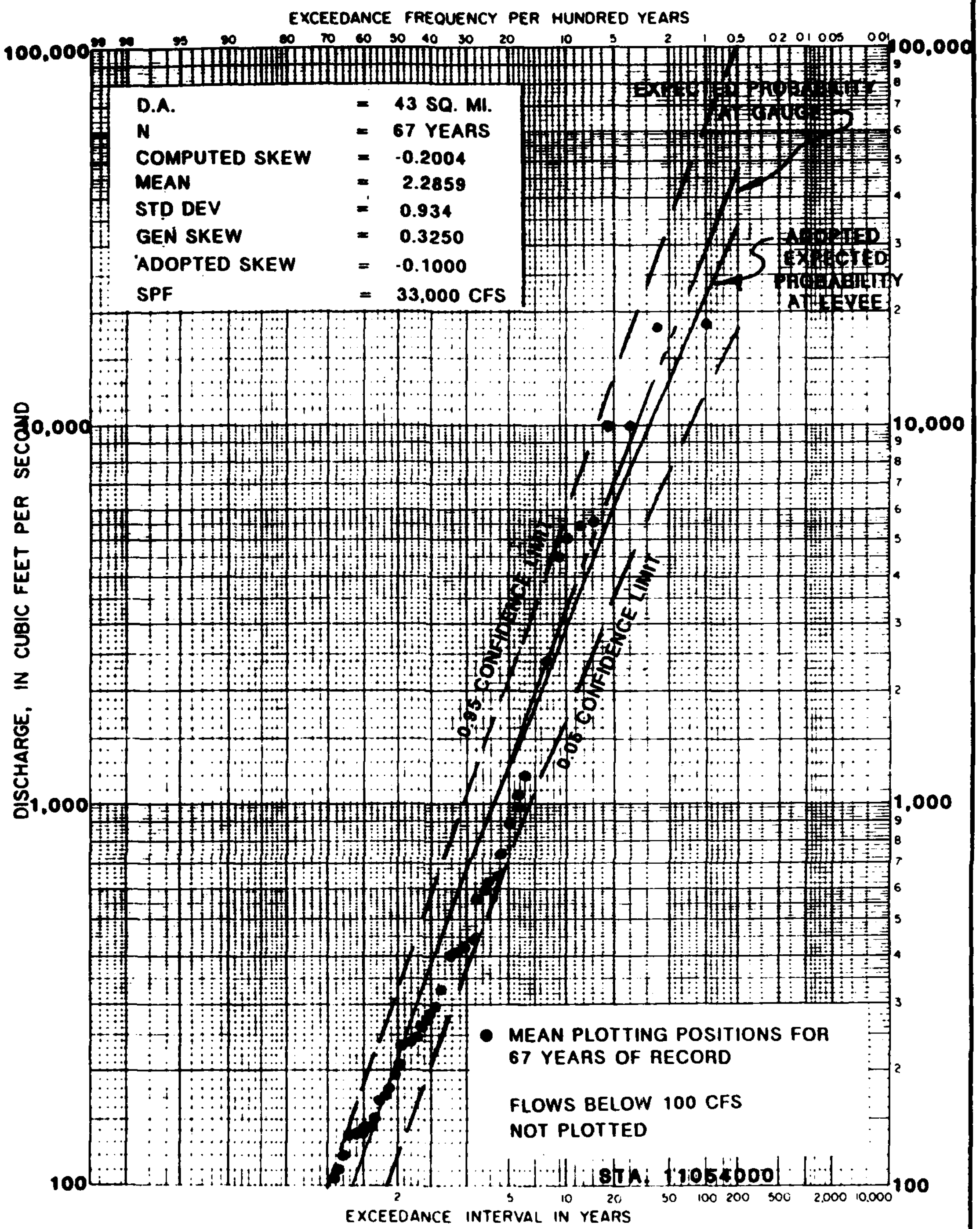
PLUNGE CREEK

NEAR EAST HIGHLAND, CA

PRESENT AND FUTURE CONDITIONS

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

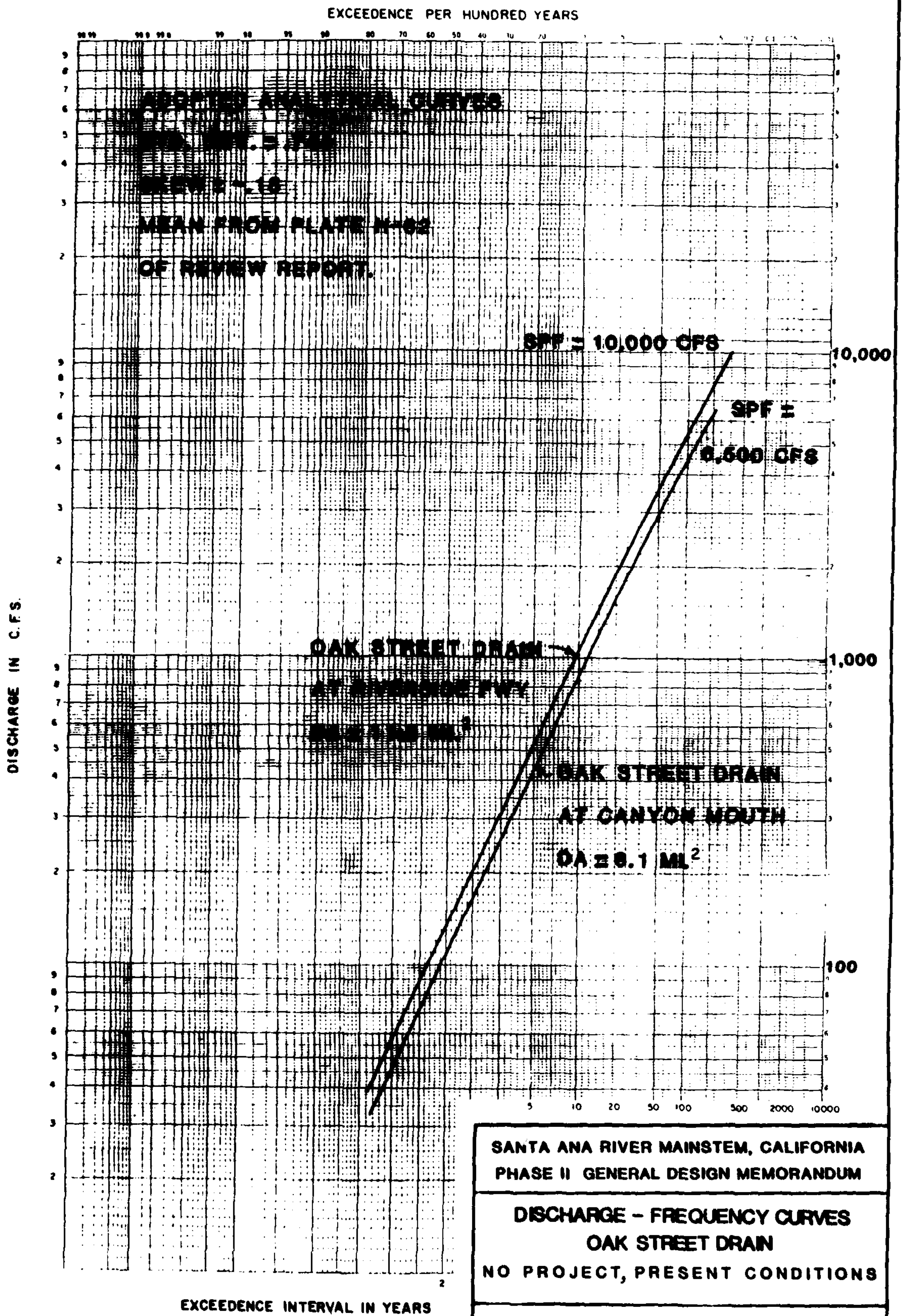
PLATE 7-55



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DISCHARGE-FREQUENCY CURVE
MILL CREEK
NEAR YUCAIPA, CA
PRESENT AND FUTURE CONDITIONS

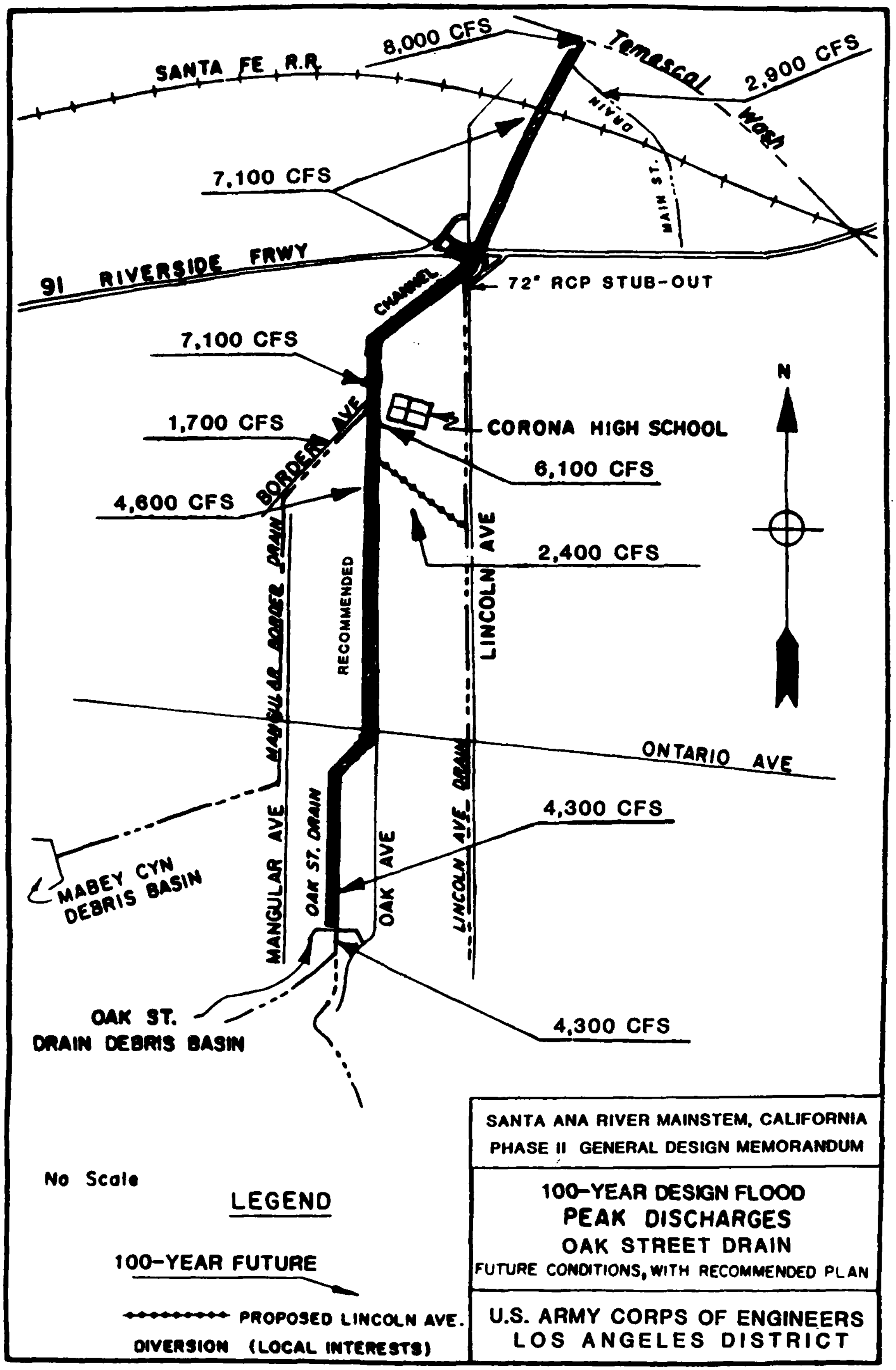
U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DISCHARGE - FREQUENCY CURVES
OAK STREET DRAIN
NO PROJECT, PRESENT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

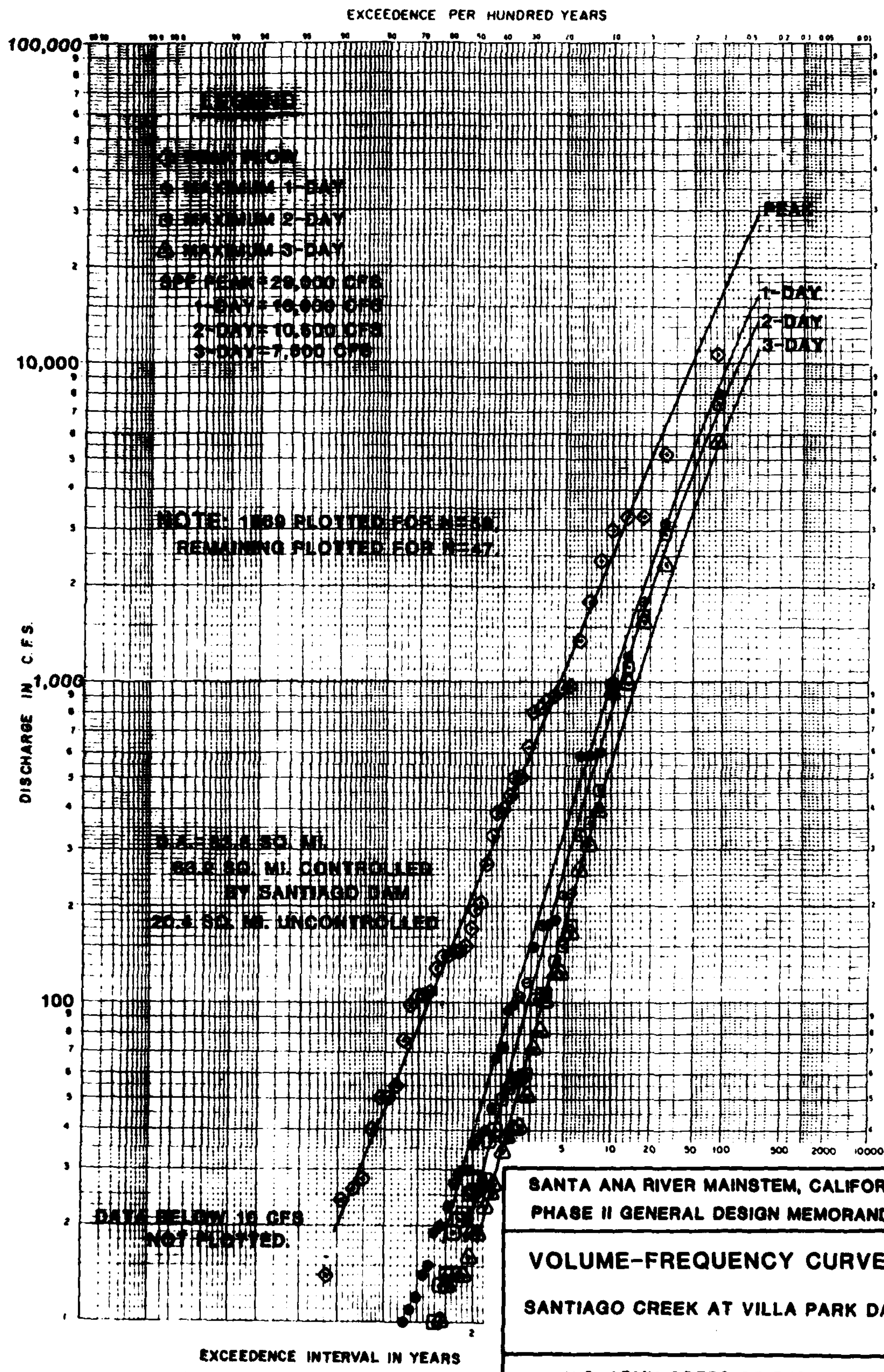


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

100-YEAR DESIGN FLOOD
PEAK DISCHARGES
OAK STREET DRAIN
FUTURE CONDITIONS, WITH RECOMMENDED PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-58



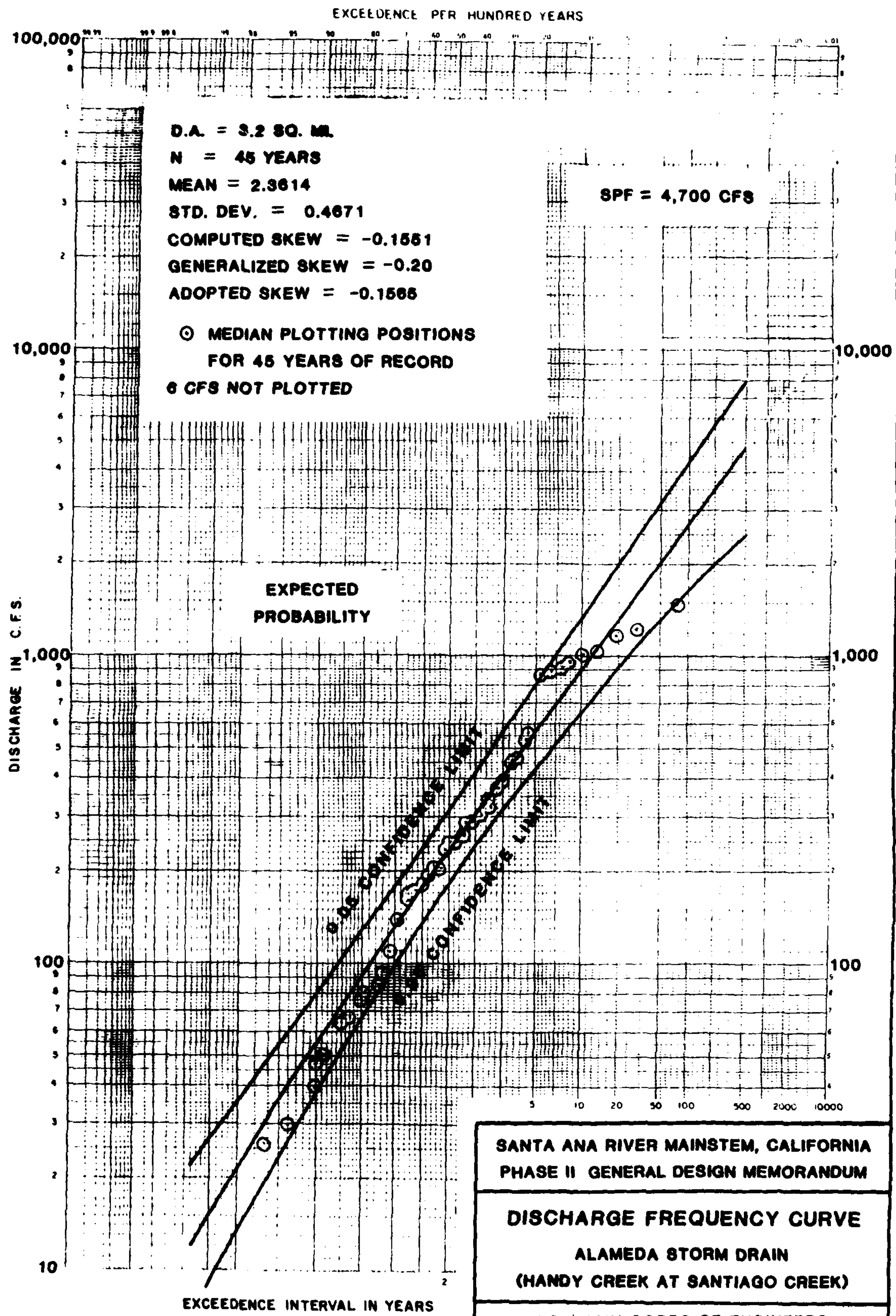
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

VOLUME-FREQUENCY CURVES

SANTIAGO CREEK AT VILLA PARK DAM

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-59

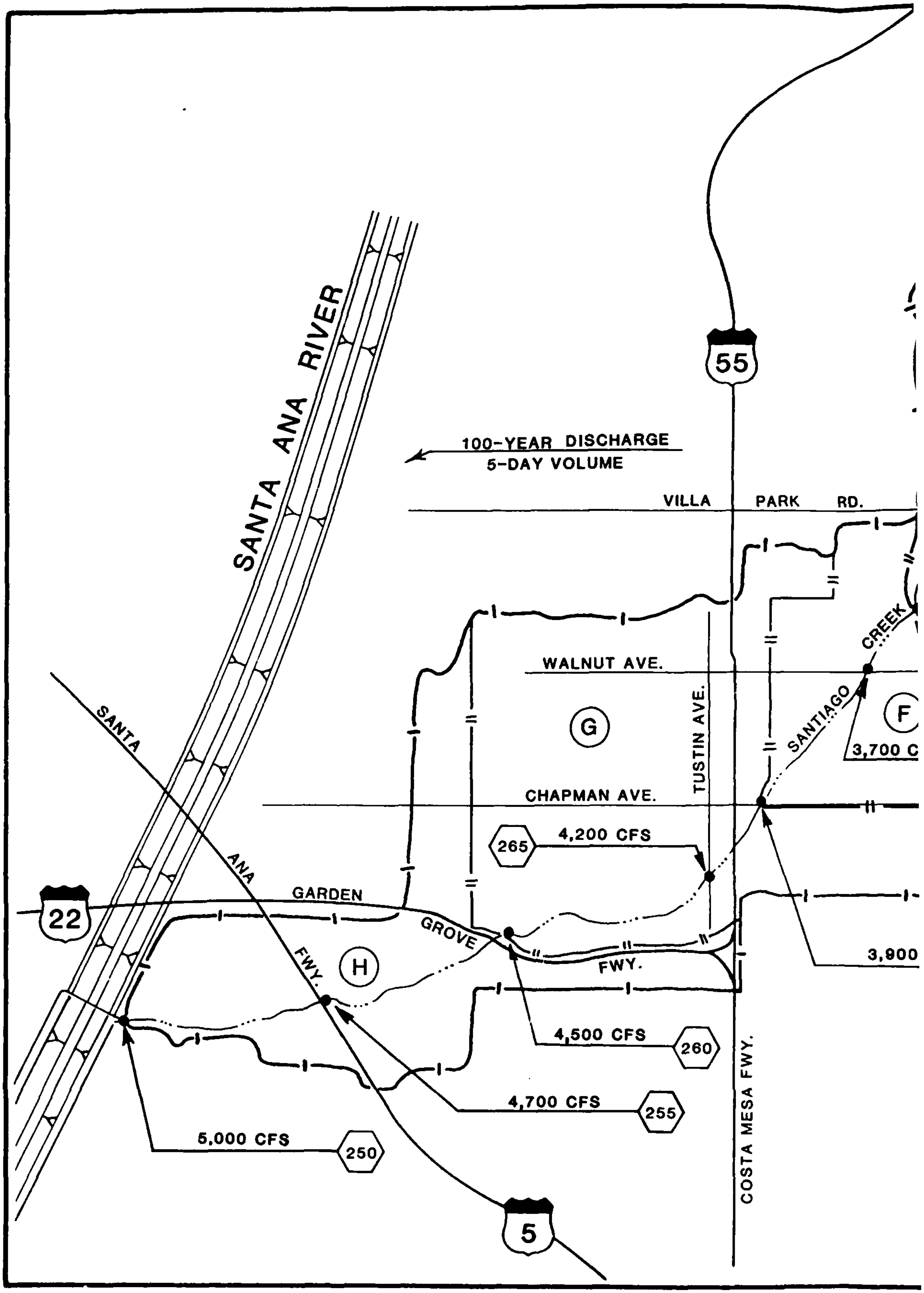


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

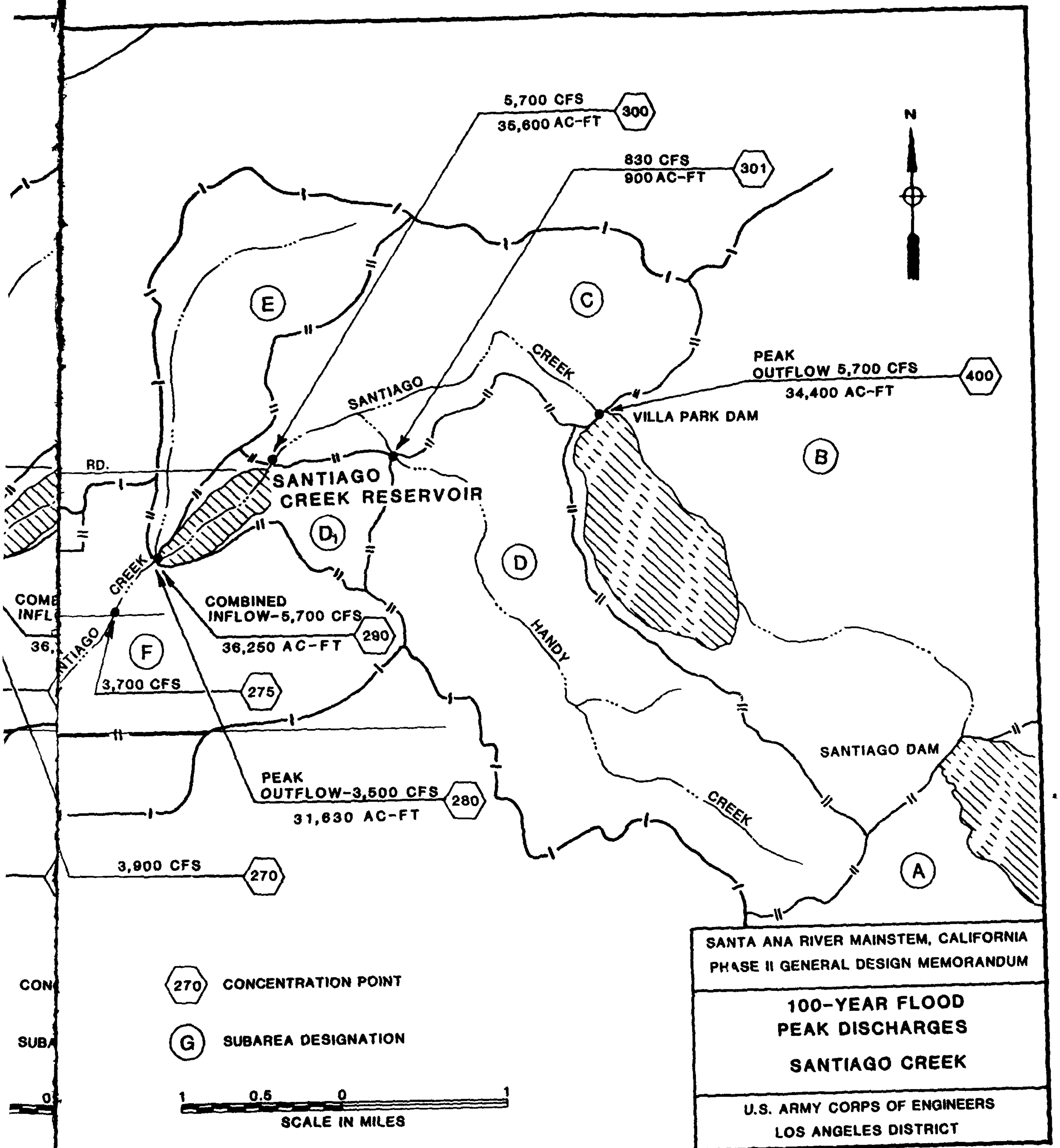
DISCHARGE FREQUENCY CURVE

ALAMEDA STORM DRAIN
(HANDY CREEK AT SANTIAGO CREEK)

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SANTA ANA RIVER
55
100-YEAR DISCHARGE
5-DAY VOLUME
VILLA PARK RD.
WALNUT AVE.
CREEK
SANTIAGO
G
F
TUSTIN AVE.
3,700 C
CHAPMAN AVE.
SANTA ANA FWY.
265
4,200 CFS
22
GARDEN GROVE FWY.
H
3,900
4,500 CFS
260
4,700 CFS
255
5,000 CFS
250
COSTA MESA FWY.
5



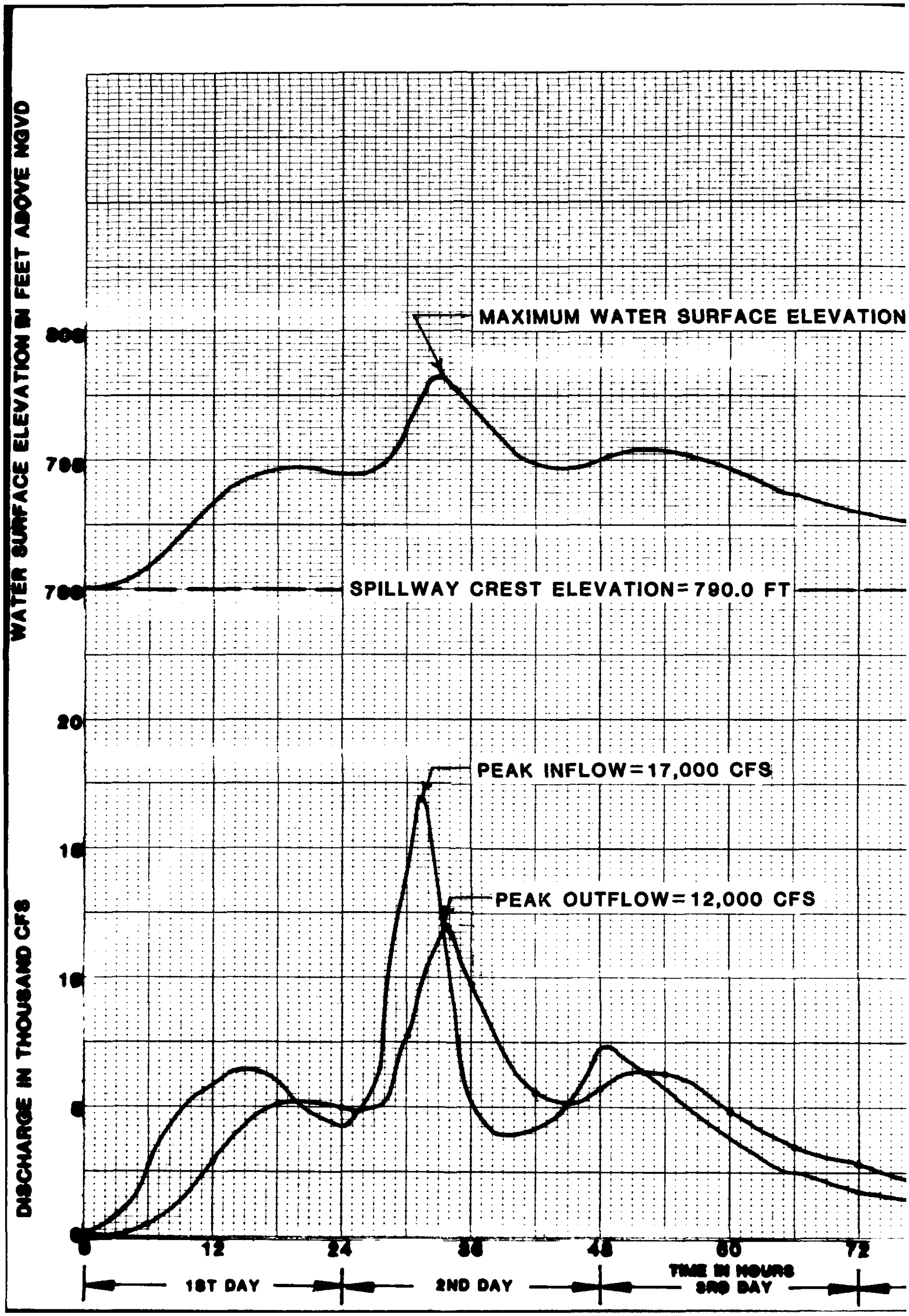
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

**100-YEAR FLOOD
PEAK DISCHARGES
SANTIAGO CREEK**

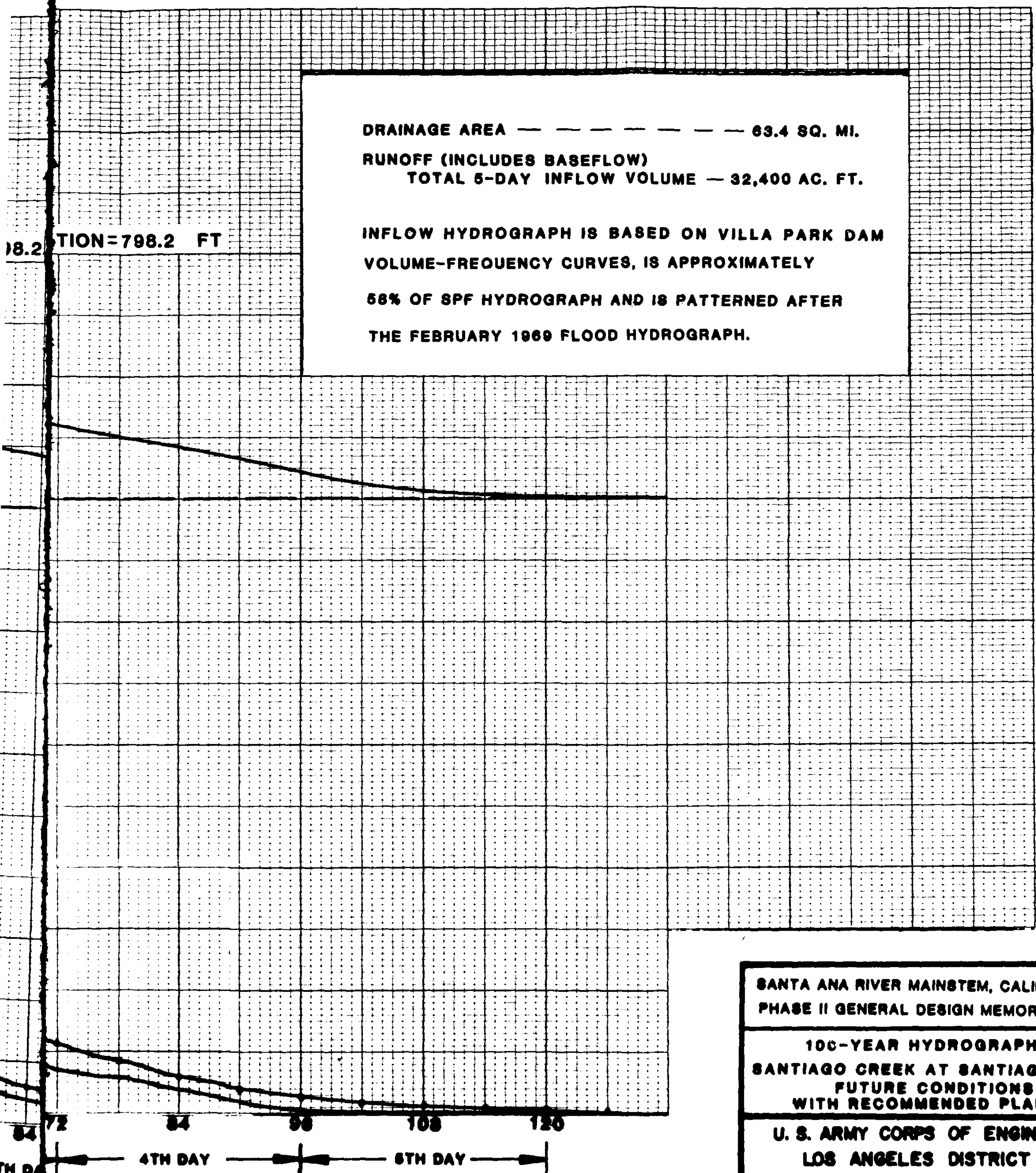
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-61

2



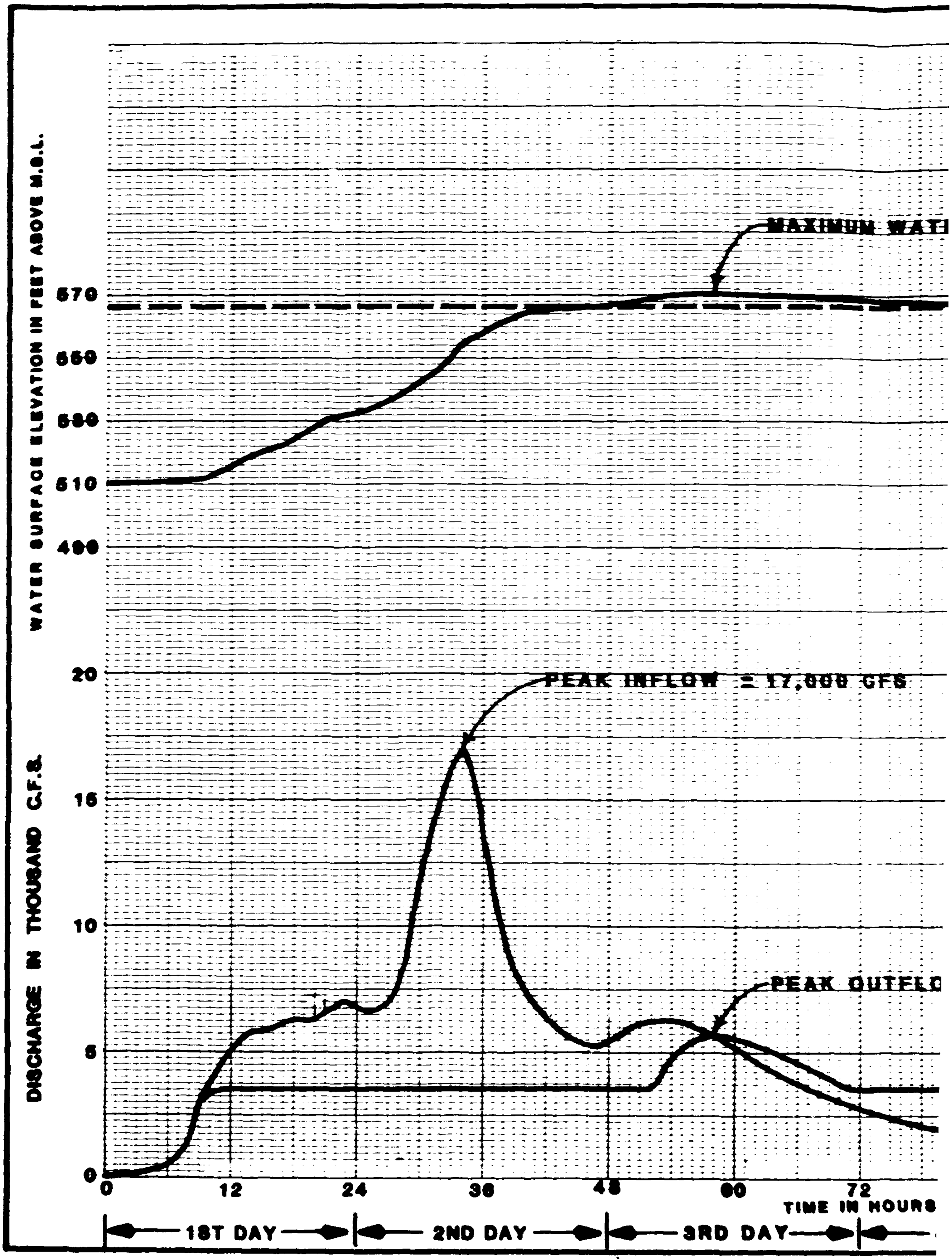
WATER SURFACE ELEVATION IN FEET ABOVE NGVD
800
795
790
MAXIMUM WATER SURFACE ELEVATION
SPILLWAY CREST ELEVATION=790.0 FT
DISCHARGE IN THOUSAND CFS
20
15
10
5
0
PEAK INFLOW=17,000 CFS
PEAK OUTFLOW=12,000 CFS
0
12
24
36
48
60
72
TIME IN HOURS
1ST DAY
2ND DAY
3RD DAY



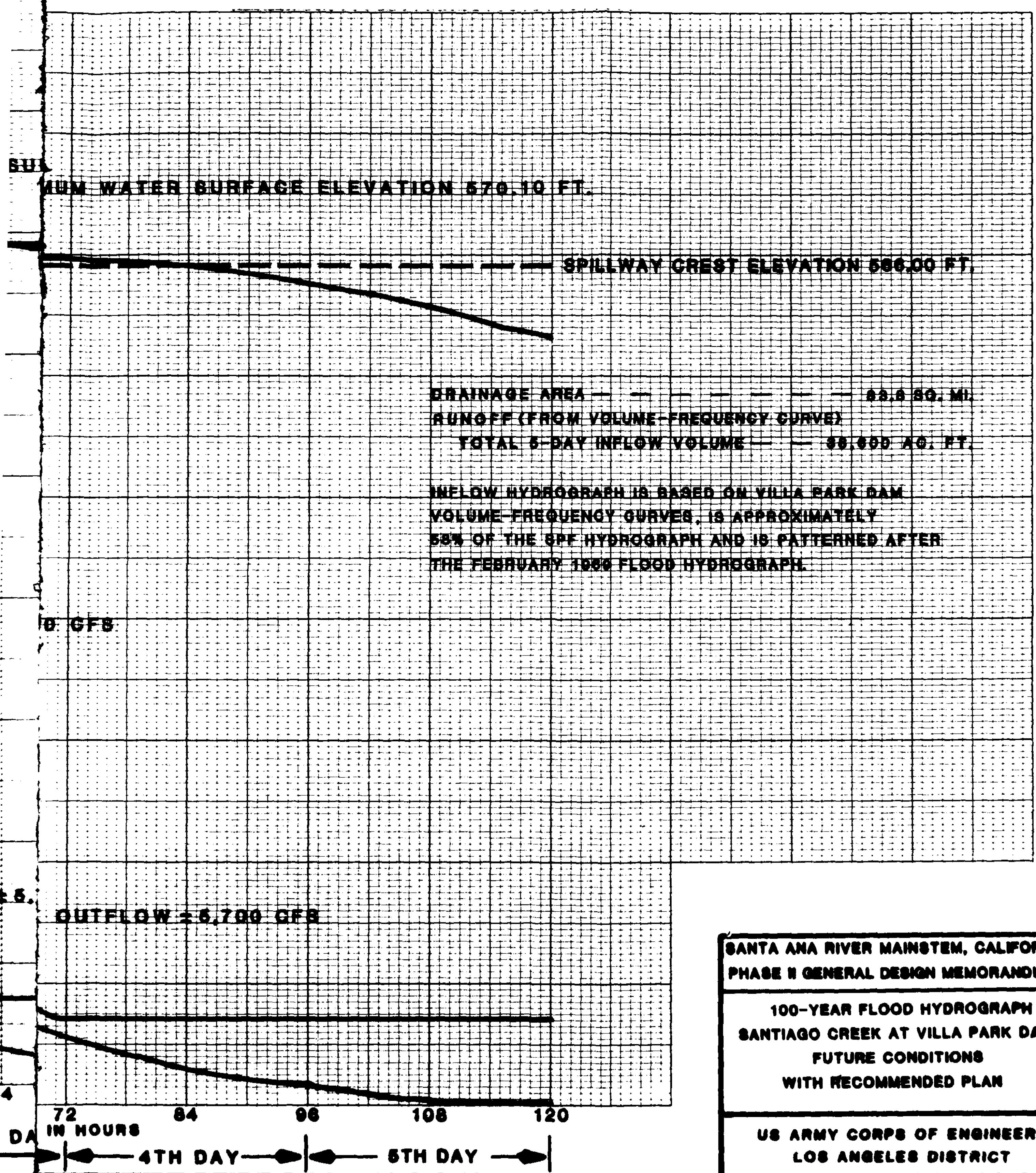
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

100-YEAR HYDROGRAPH
SANTIAGO CREEK AT SANTIAGO DAM
FUTURE CONDITIONS
WITH RECOMMENDED PLAN

U. S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



MAXIMUM WAT
570
550
530
510
490
WATER SURFACE ELEVATION IN FEET ABOVE M.S.L.
20
PEAK INFLOW = 17,000 CFS
15
10
PEAK OUTFLO
5
0
DISCHARGE IN THOUSAND C.F.S.
0
12
24
36
48
60
72
TIME IN HOURS
1ST DAY
2ND DAY
3RD DAY



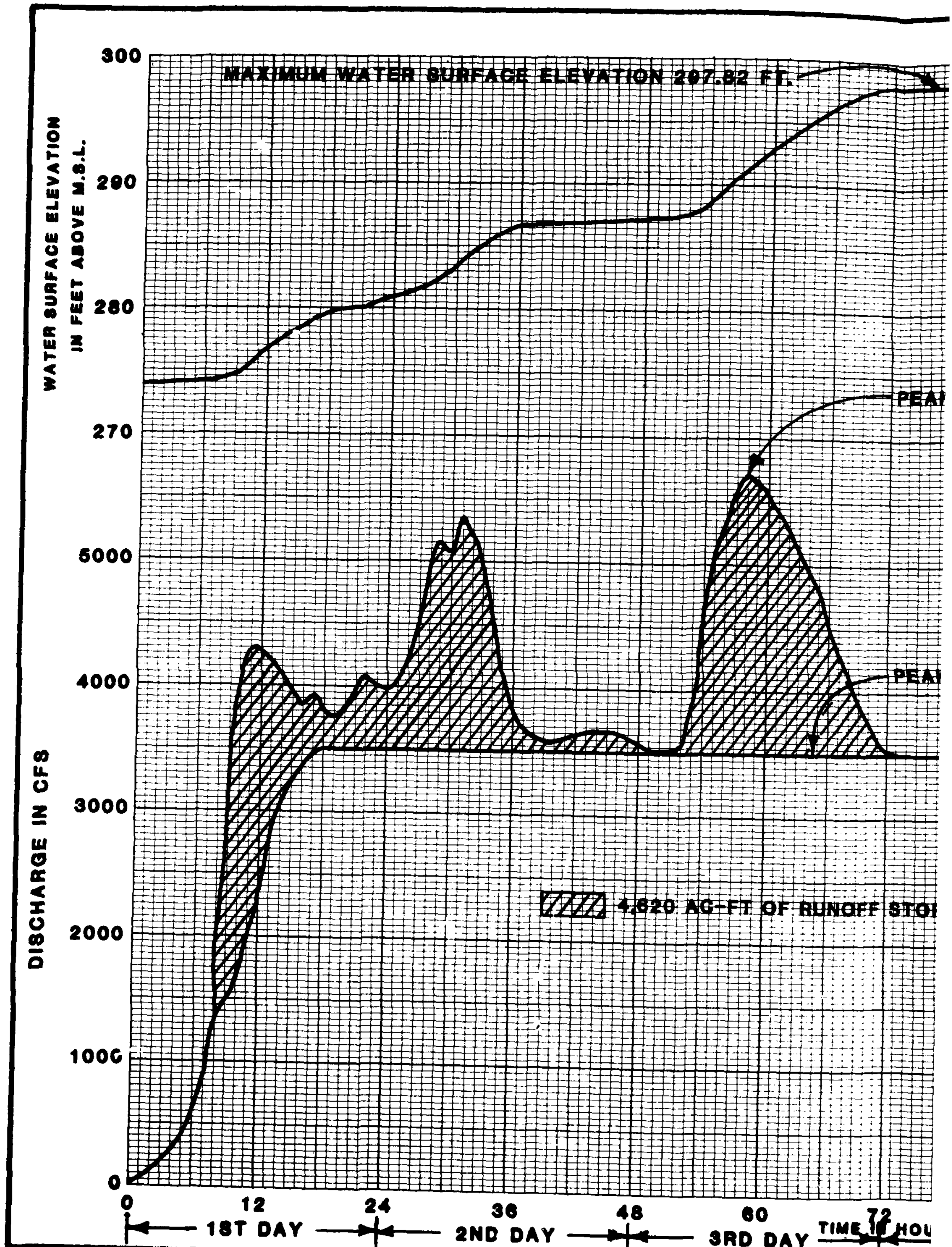
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

100-YEAR FLOOD HYDROGRAPH
SANTIAGO CREEK AT VILLA PARK DAM
FUTURE CONDITIONS
WITH RECOMMENDED PLAN

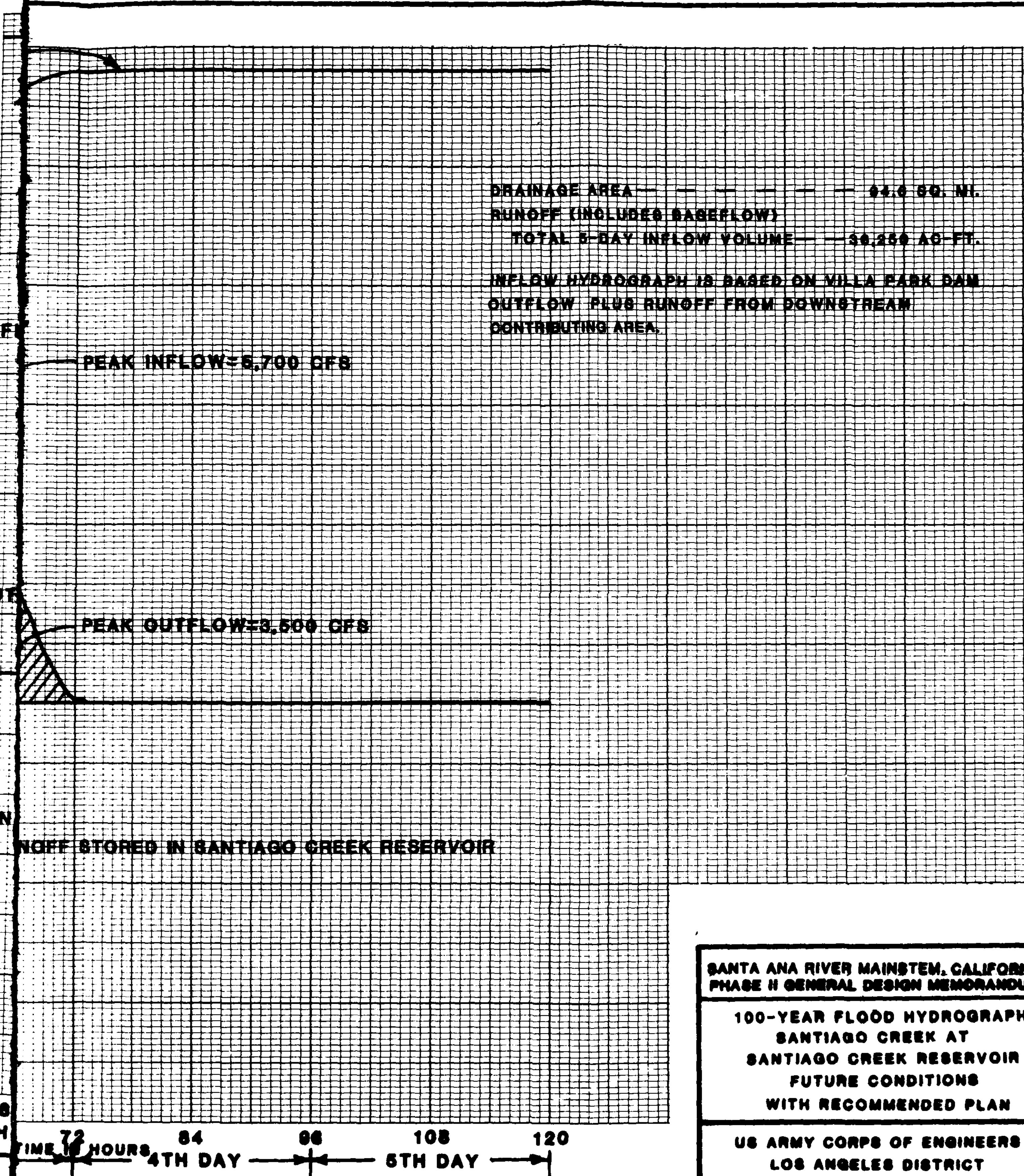
US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-63

2



MAXIMUM WATER SURFACE ELEVATION 297.82 FT.
WATER SURFACE ELEVATION IN FEET ABOVE M.S.L.
300
290
280
270
5000
4000
3000
2000
1000
0
DISCHARGE IN CFS
4,620 AC-FT OF RUNOFF STO
0
12
24
36
48
60
72
1ST DAY
2ND DAY
3RD DAY
TIME IN HOU



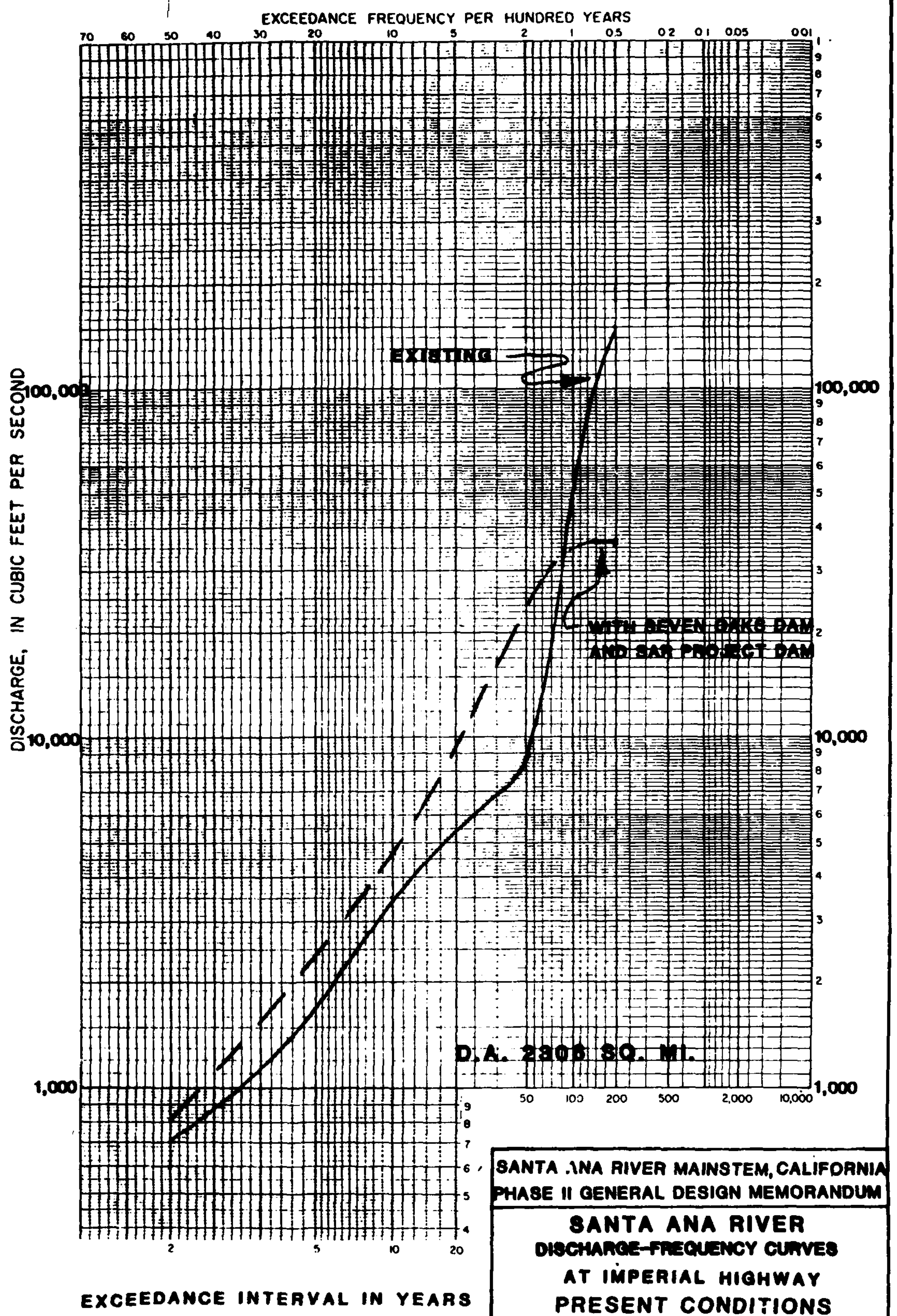
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

100-YEAR FLOOD HYDROGRAPH
SANTIAGO CREEK AT
SANTIAGO CREEK RESERVOIR
FUTURE CONDITIONS
WITH RECOMMENDED PLAN

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-64

1 2

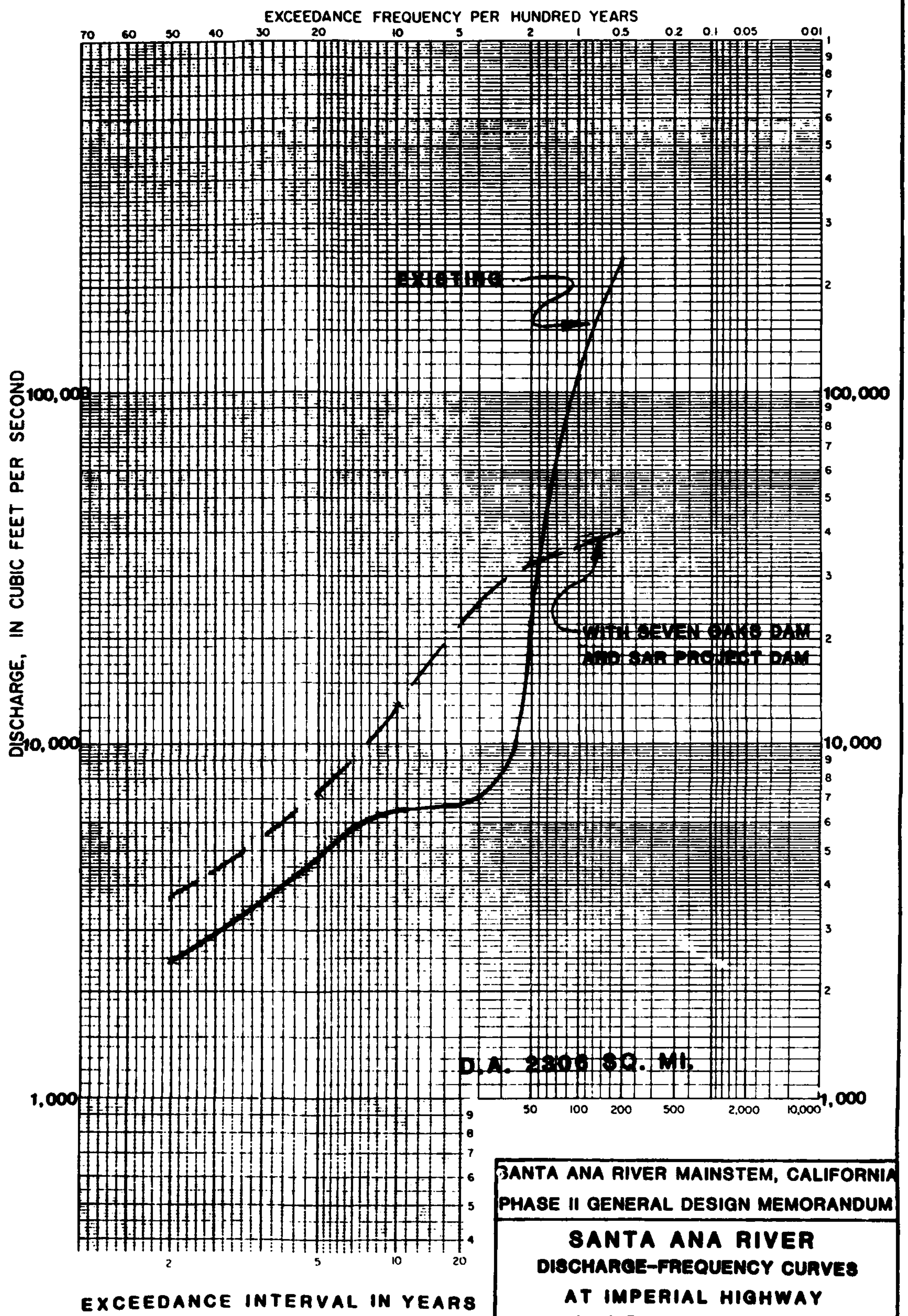


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT IMPERIAL HIGHWAY
PRESENT CONDITIONS

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

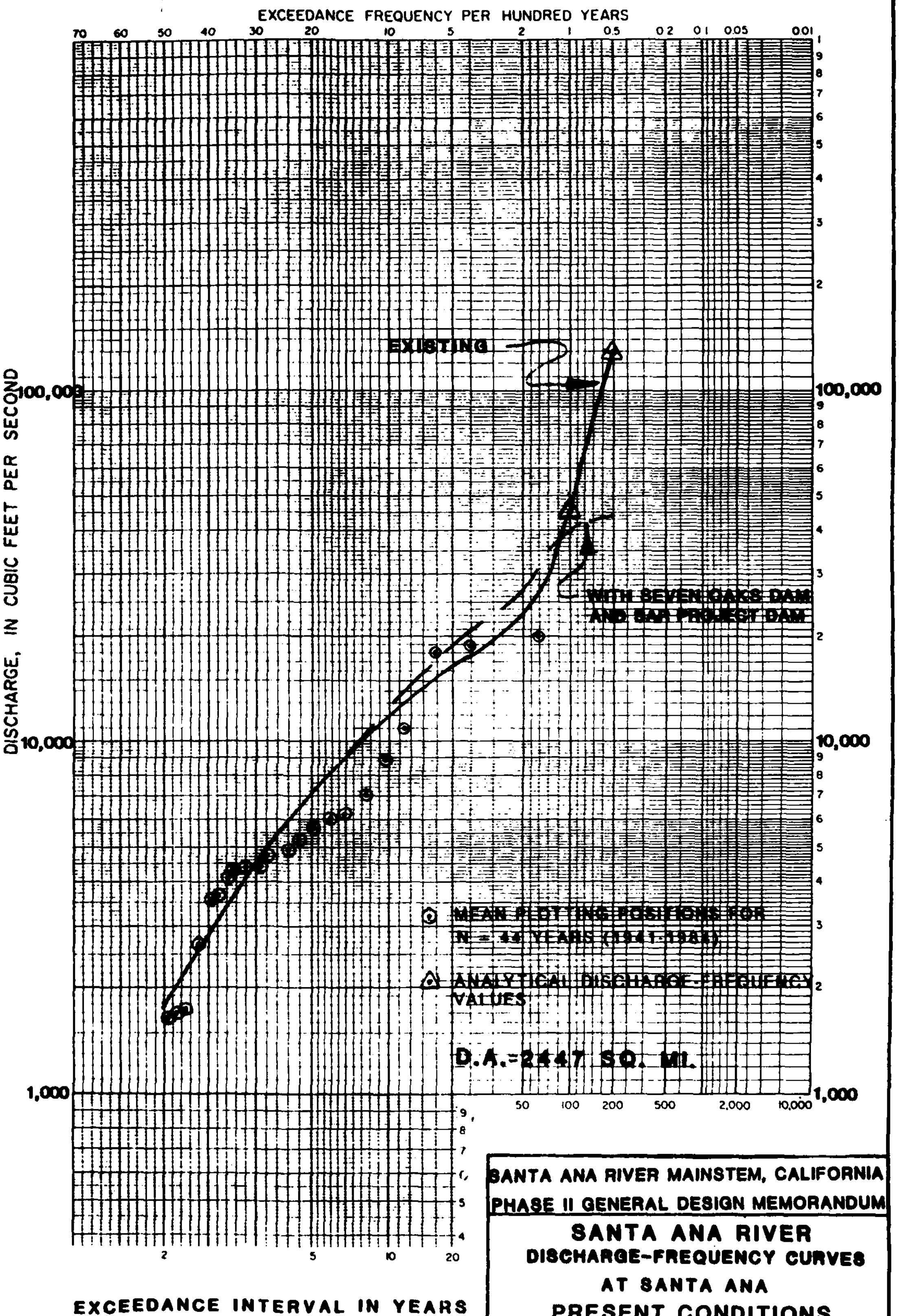
PLATE 7-65



SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT IMPERIAL HIGHWAY
FUTURE CONDITIONS

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

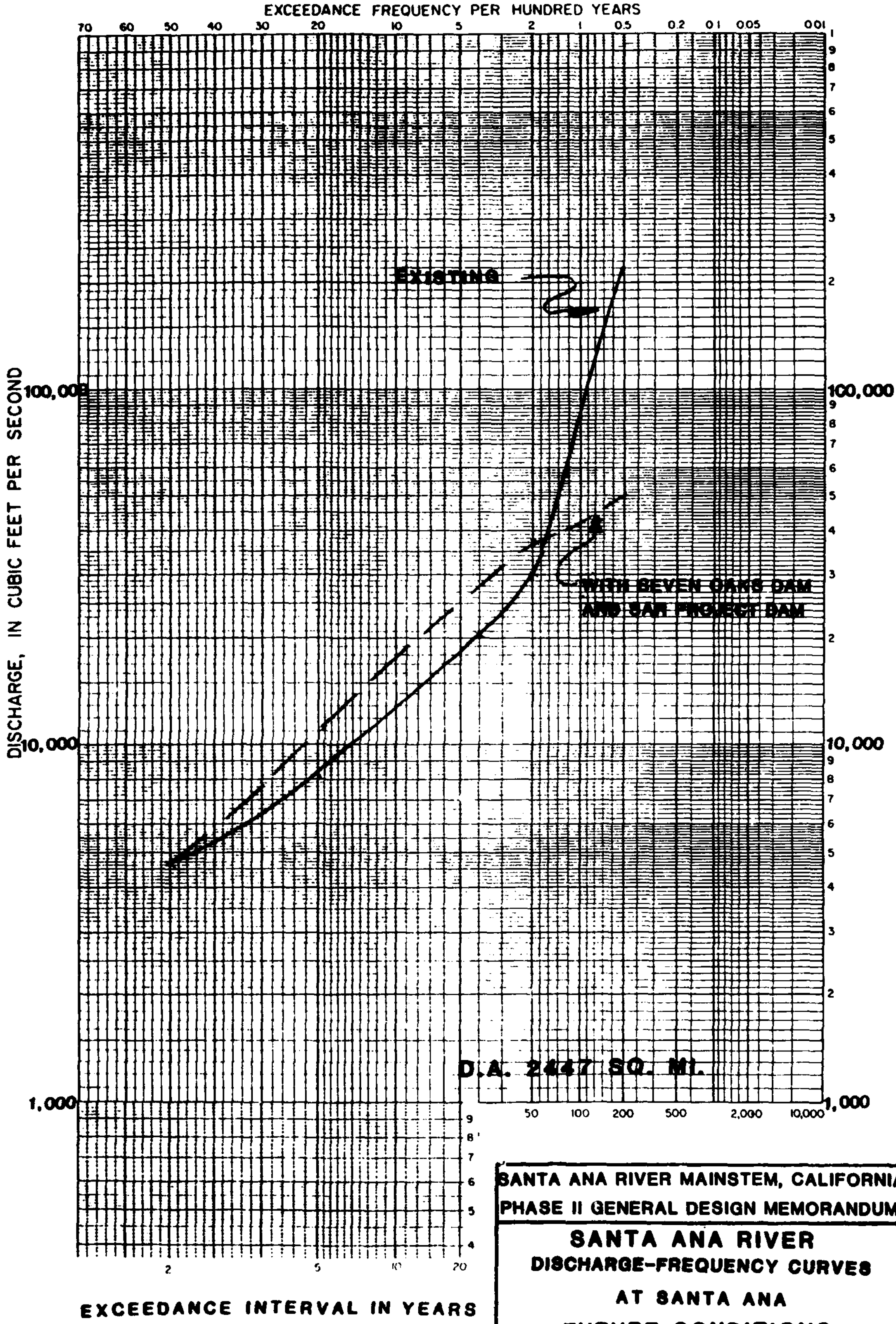


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT SANTA ANA
PRESENT CONDITIONS

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

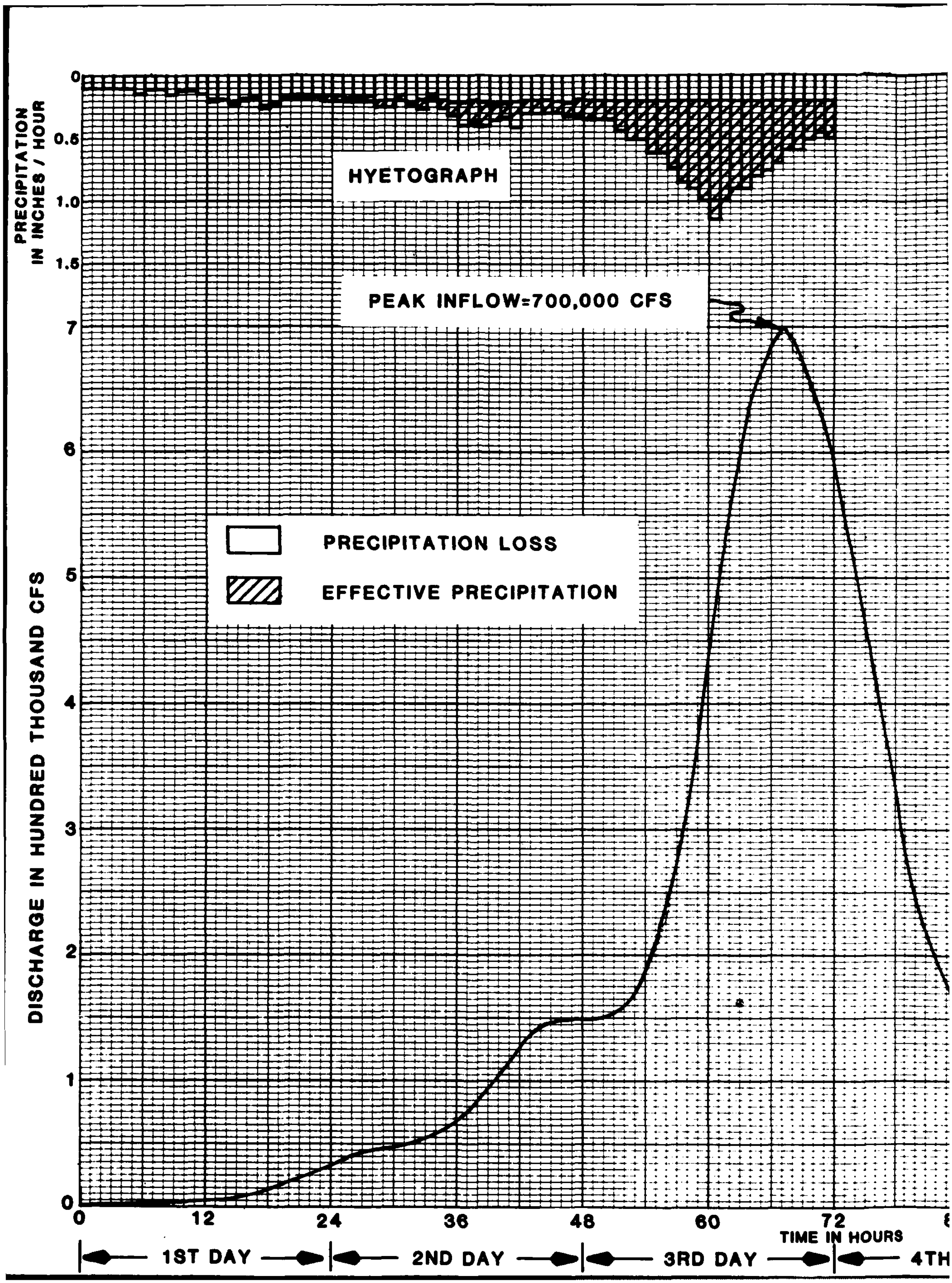
PLATE 7-67



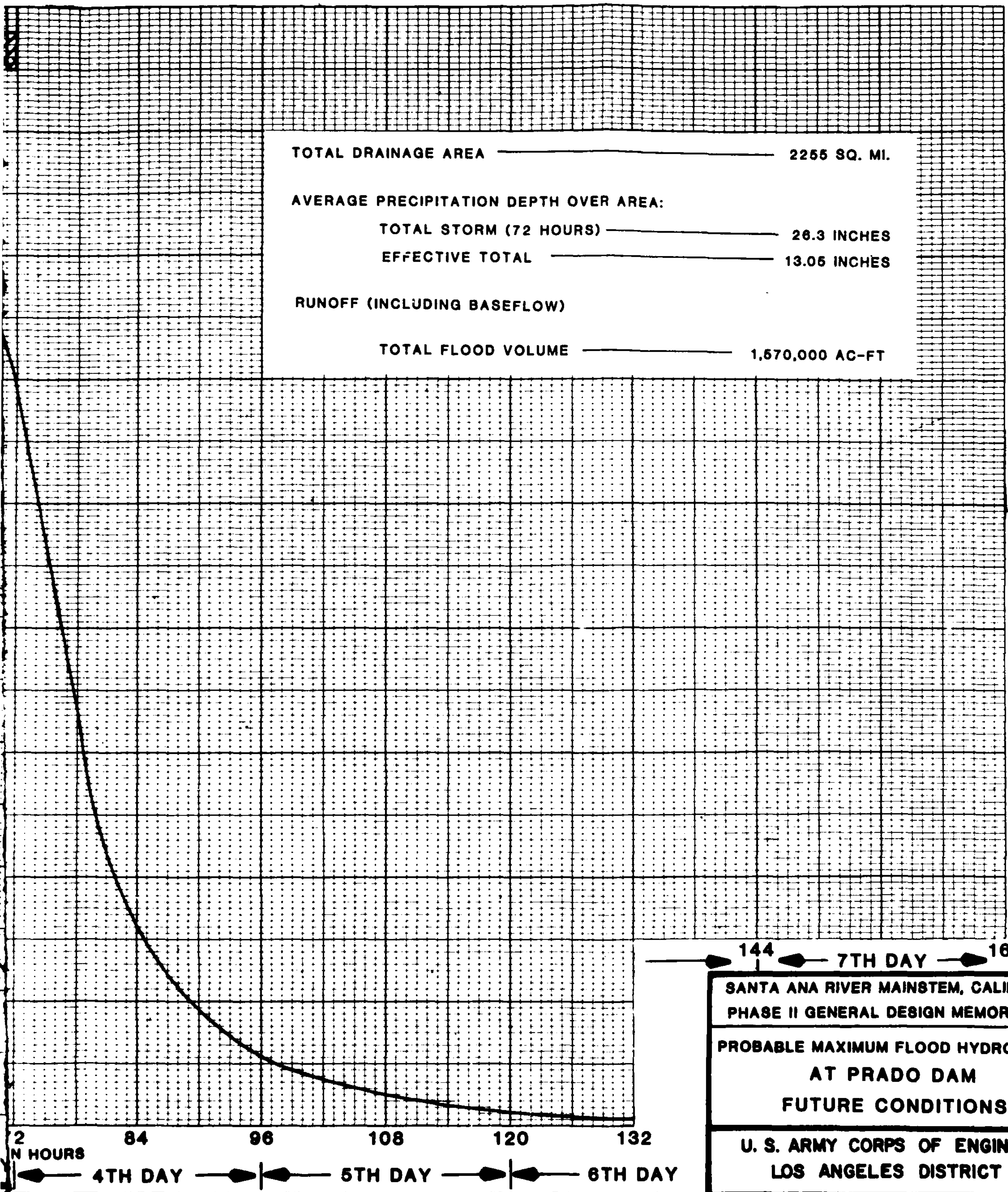
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
DISCHARGE-FREQUENCY CURVES
AT SANTA ANA
FUTURE CONDITIONS

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



PRECIPITATION IN INCHES / HOUR
0
0.5
1.0
1.5
HYETOGRAPH
PEAK INFLOW=700,000 CFS
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
DISCHARGE IN HUNDRED THOUSAND CFS
0
1
2
3
4
5
6
7
0
12
24
36
48
60
72
TIME IN HOURS
1ST DAY
2ND DAY
3RD DAY
4TH



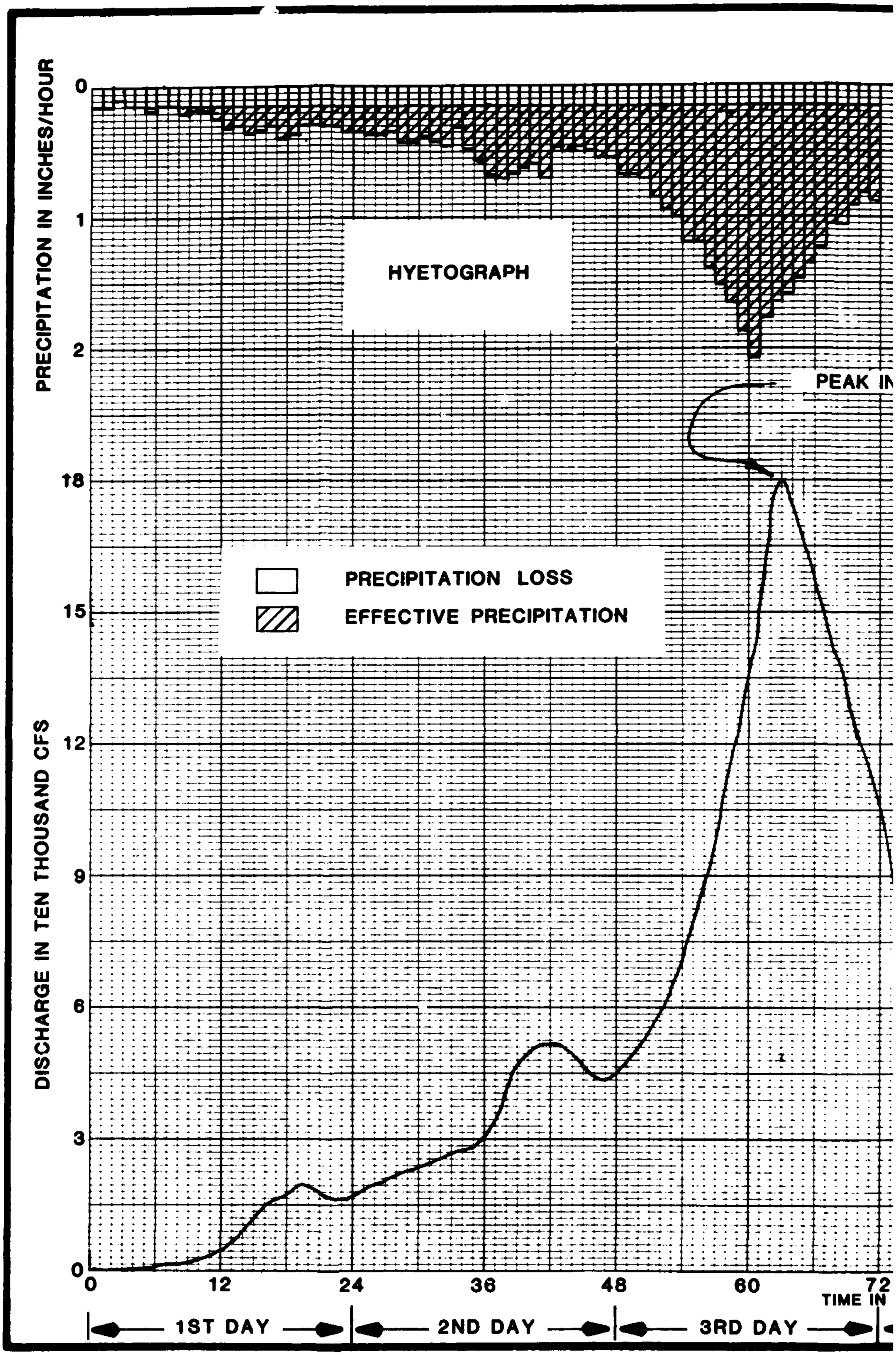
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PROBABLE MAXIMUM FLOOD HYDROGRAPH
AT PRADO DAM
FUTURE CONDITIONS

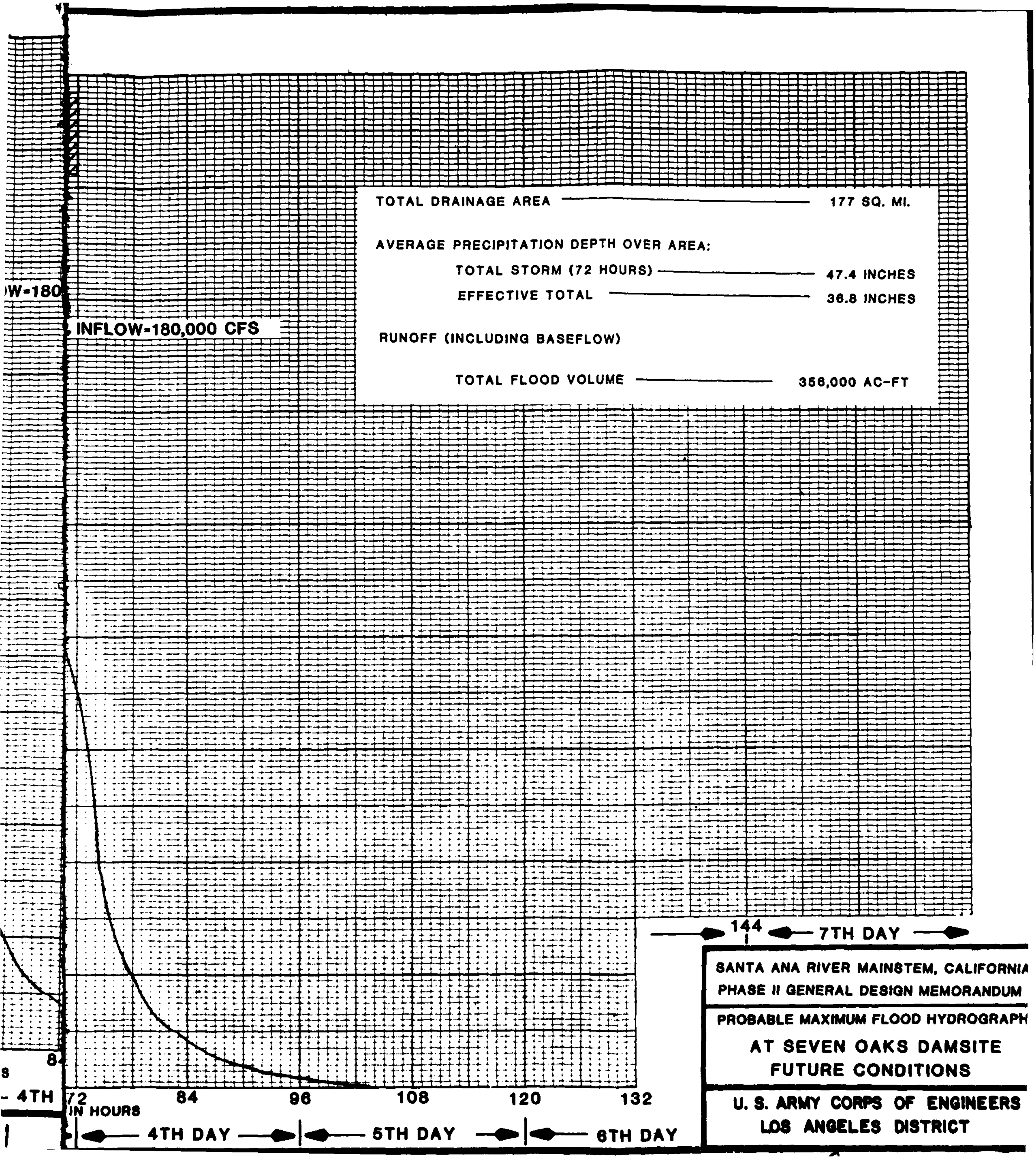
U. S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

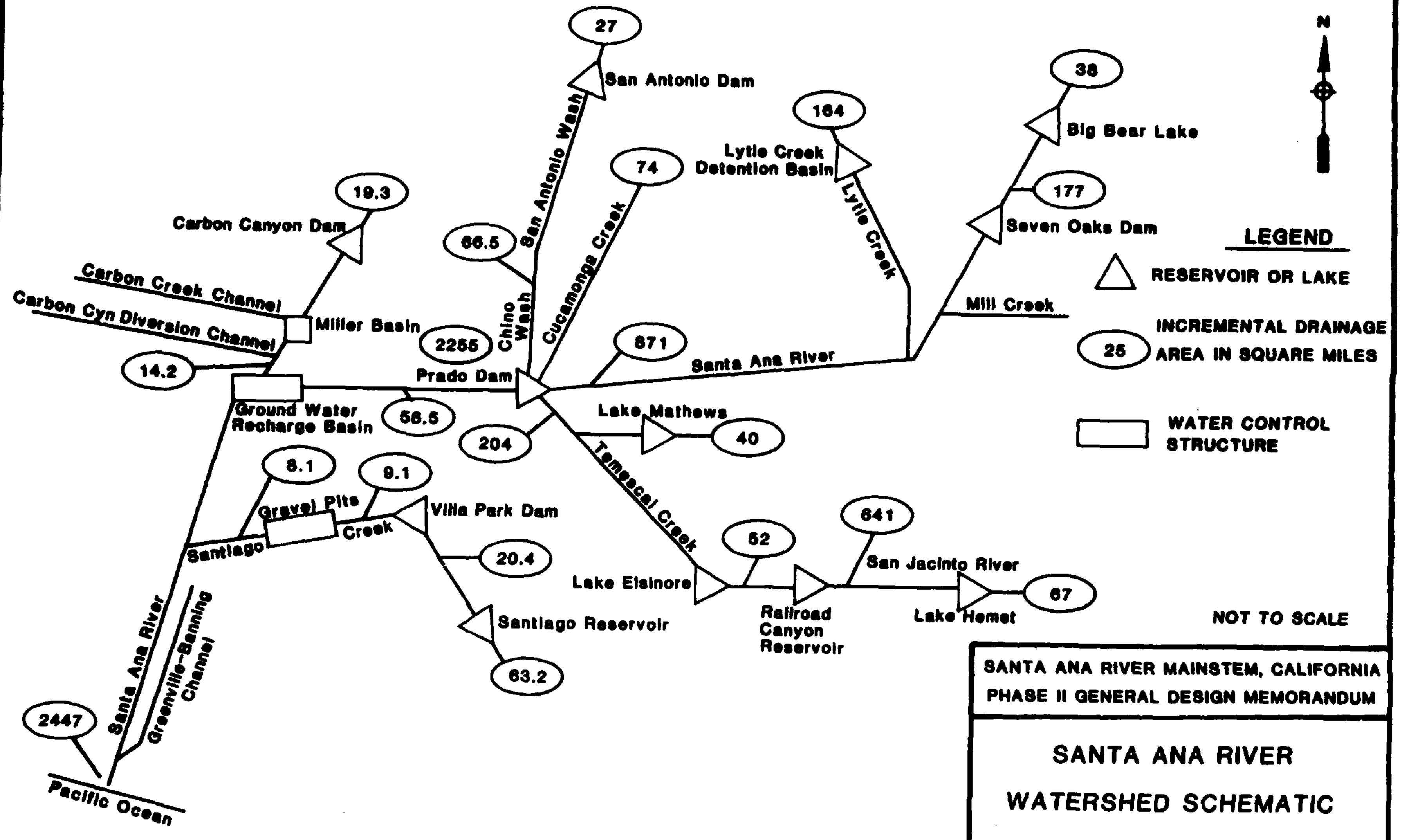
2

PLATE 7-69



PRECIPITATION IN INCHES/HOUR
0
1
2
HYETOGRAPH
PEAK IN
18
15
12
9
6
3
0
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
DISCHARGE IN TEN THOUSAND CFS
0
12
24
36
48
60
72
TIME IN
1ST DAY
2ND DAY
3RD DAY


TOTAL DRAINAGE AREA 177 SQ. MI.
AVERAGE PRECIPITATION DEPTH OVER AREA:
TOTAL STORM (72 HOURS) 47.4 INCHES
EFFECTIVE TOTAL 36.8 INCHES
RUNOFF (INCLUDING BASEFLOW)
TOTAL FLOOD VOLUME 356,000 AC-FT
W-180
INFLOW-180,000 CFS
84
S
- 4TH
72
IN HOURS
84
96
108
120
132
144
4TH DAY
5TH DAY
6TH DAY
7TH DAY
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
PROBABLE MAXIMUM FLOOD HYDROGRAPH
AT SEVEN OAKS DAMSITE
FUTURE CONDITIONS
U. S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

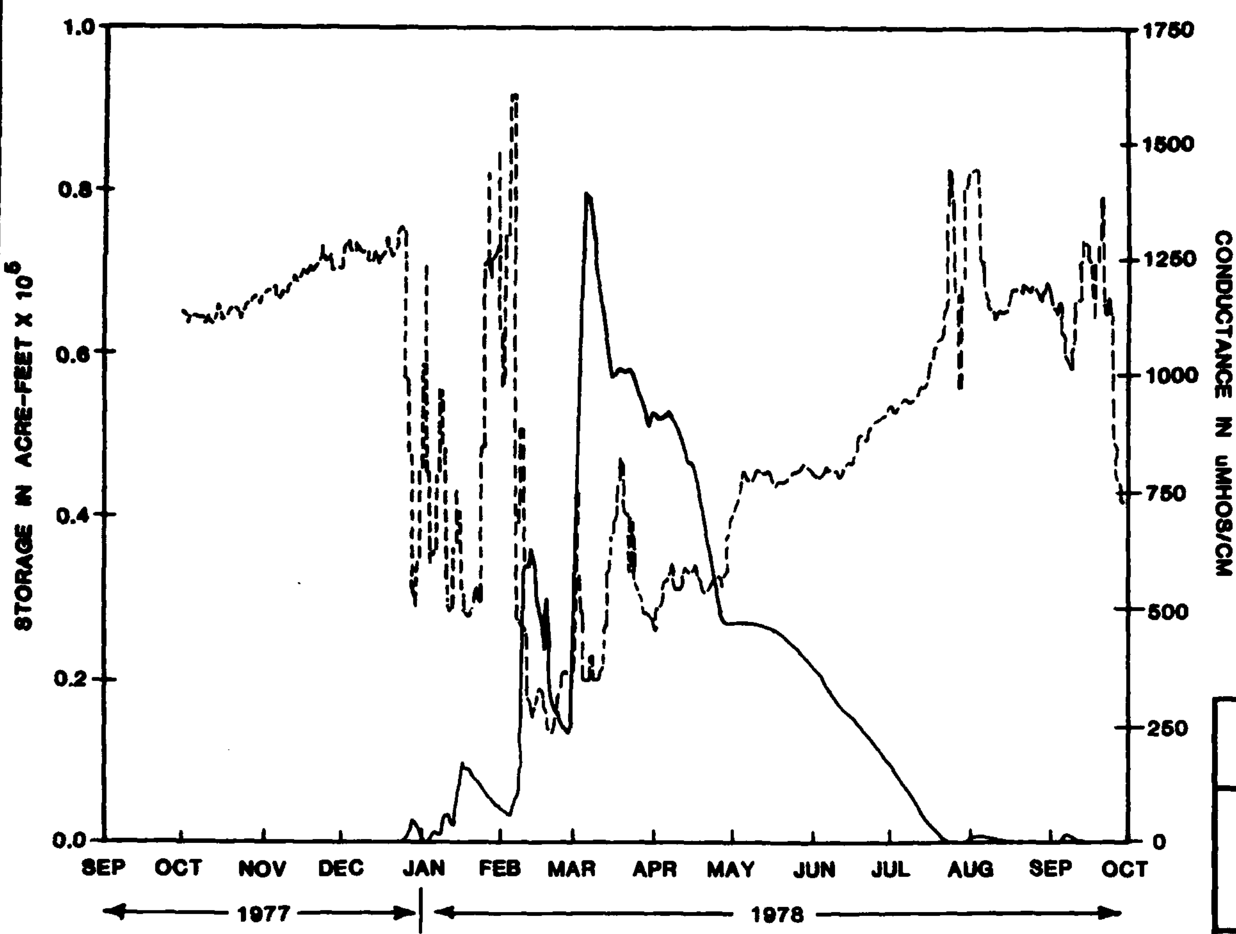


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SANTA ANA RIVER
WATERSHED SCHEMATIC

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-71

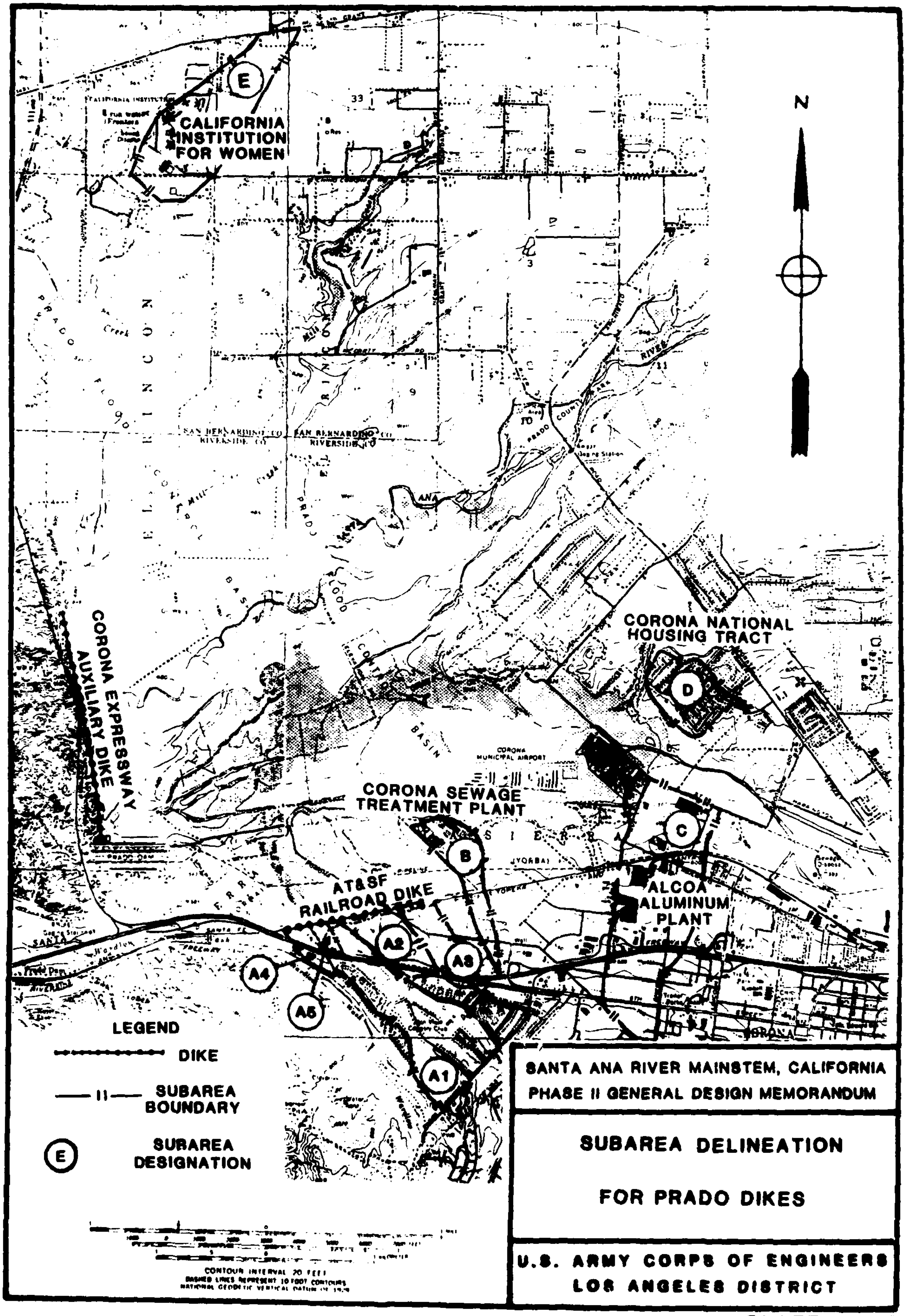


SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

RECORDED STORAGE FOR PRADO DAM
AND ELECTRICAL CONDUCTANCE
OF OUTFLOW FOR WATER YEAR 1978

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-72



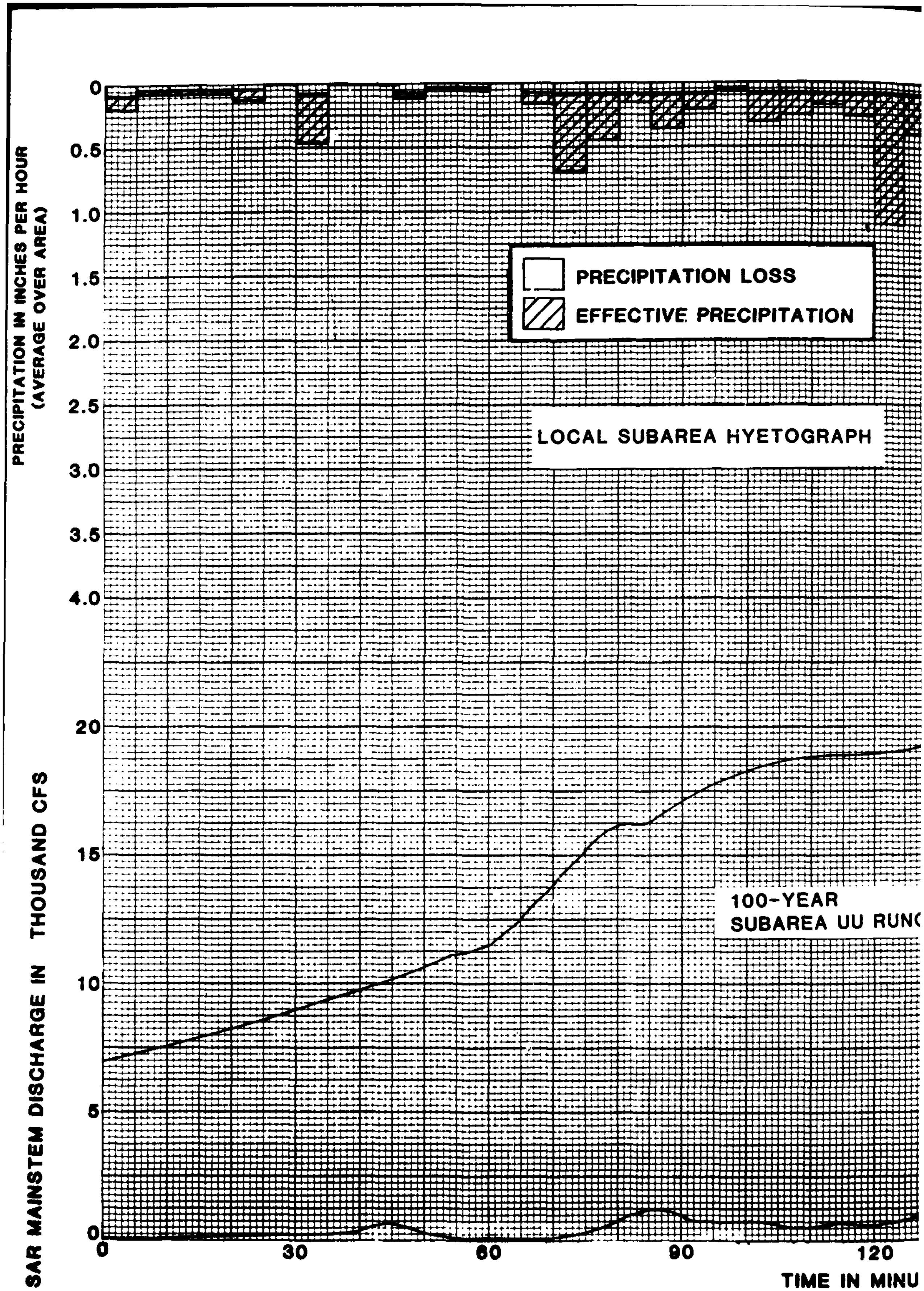
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

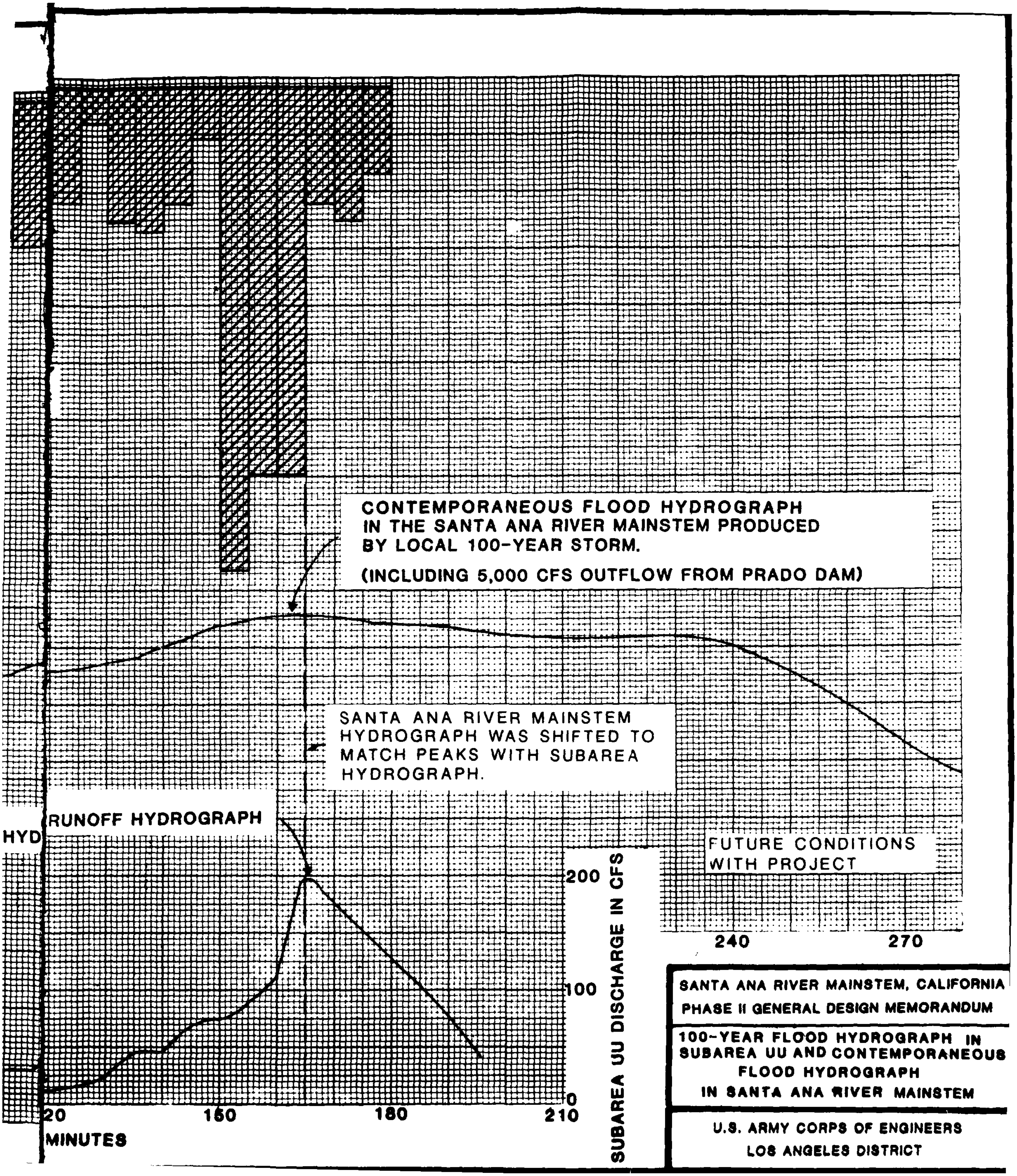
SUBAREA DELINEATION

FOR PRADO DIKES

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 7-73


PRECIPITATION IN INCHES PER HOUR
(AVERAGE OVER AREA)
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
LOCAL SUBAREA HYETOGRAPH
SAR MAINSTEM DISCHARGE IN THOUSAND CFS
20
15
10
5
0
100-YEAR
SUBAREA UU RUN
0
30
60
90
120
TIME IN MINU

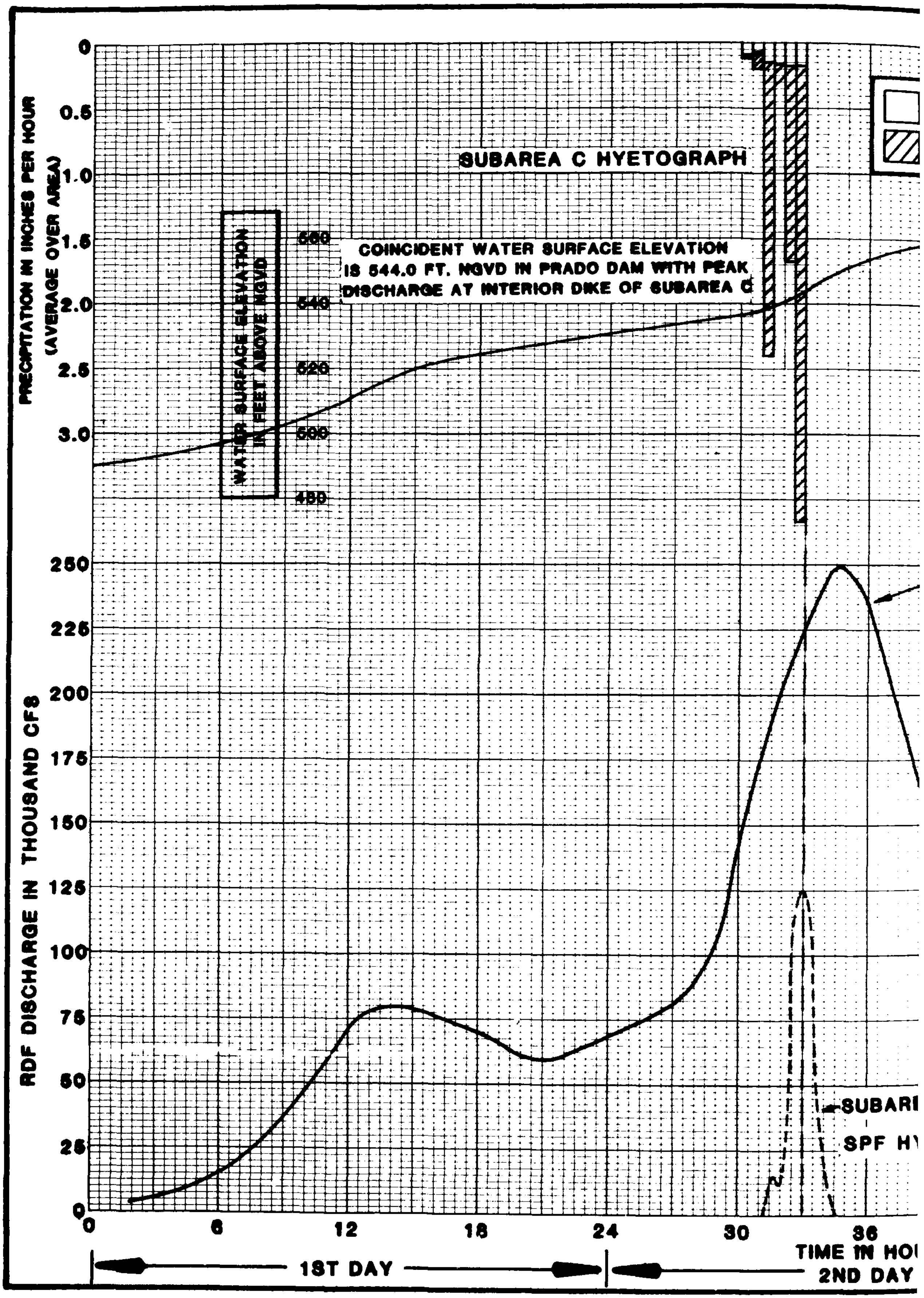


SANTA ANA RIVER MAINSTEM, CALIFORNIA

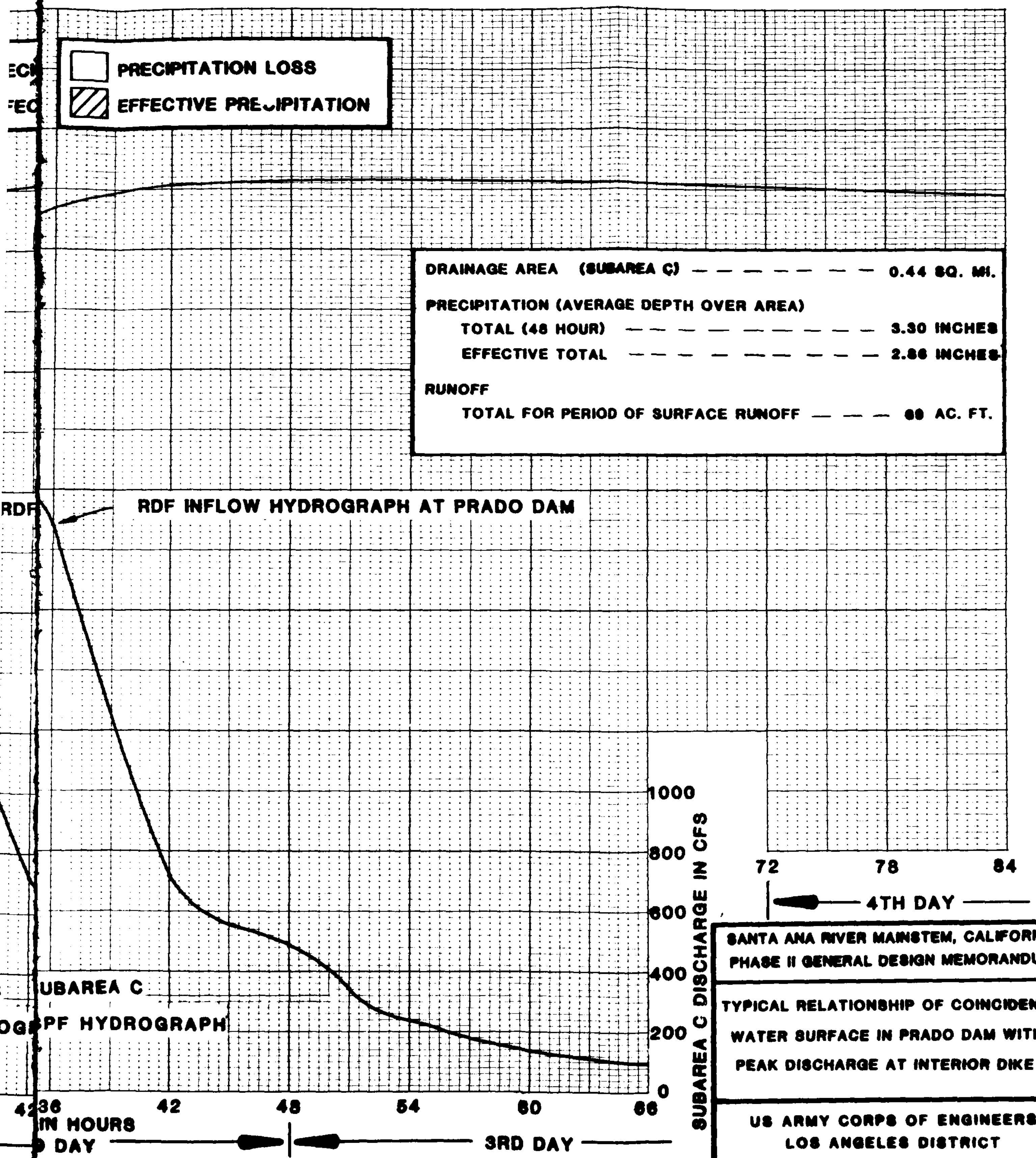
PHASE II GENERAL DESIGN MEMORANDUM

100-YEAR FLOOD HYDROGRAPH IN SUBAREA UU AND CONTEMPORANEOUS FLOOD HYDROGRAPH IN SANTA ANA RIVER MAINSTEM

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



SUBAREA C HYETOGRAPH
PRECIPITATION IN INCHES PER HOUR (AVERAGE OVER AREA)
0
0.5
1.0
1.5
2.0
2.5
3.0
WATER SURFACE ELEVATION IN FEET ABOVE NGVD
560
540
520
500
480
COINCIDENT WATER SURFACE ELEVATION IS 544.0 FT. NGVD IN PRADO DAM WITH PEAK DISCHARGE AT INTERIOR DIKE OF SUBAREA C
RDF DISCHARGE IN THOUSAND CFS
250
225
200
175
150
125
100
75
50
25
0
SUBARI
SPF H
0
6
12
18
24
30
36
TIME IN HO
1ST DAY
2ND DAY

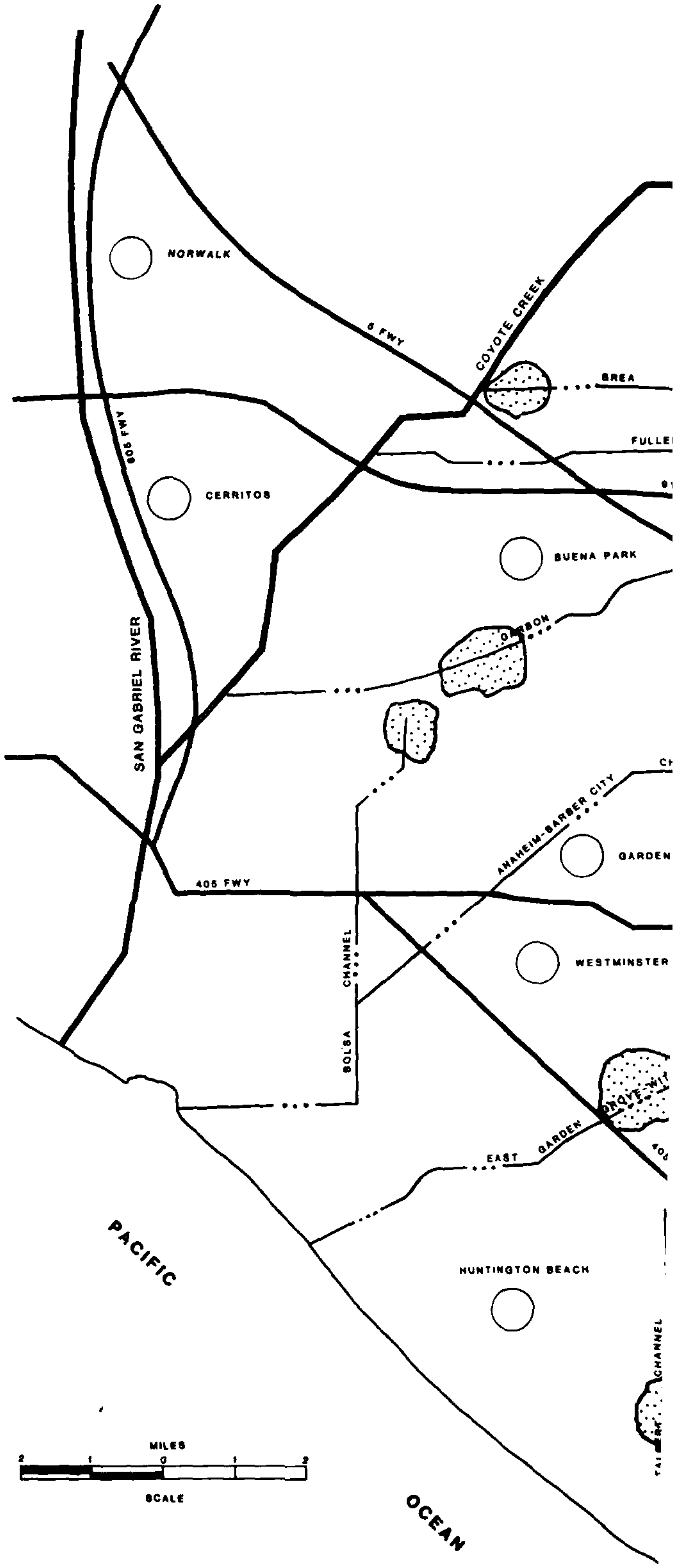


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

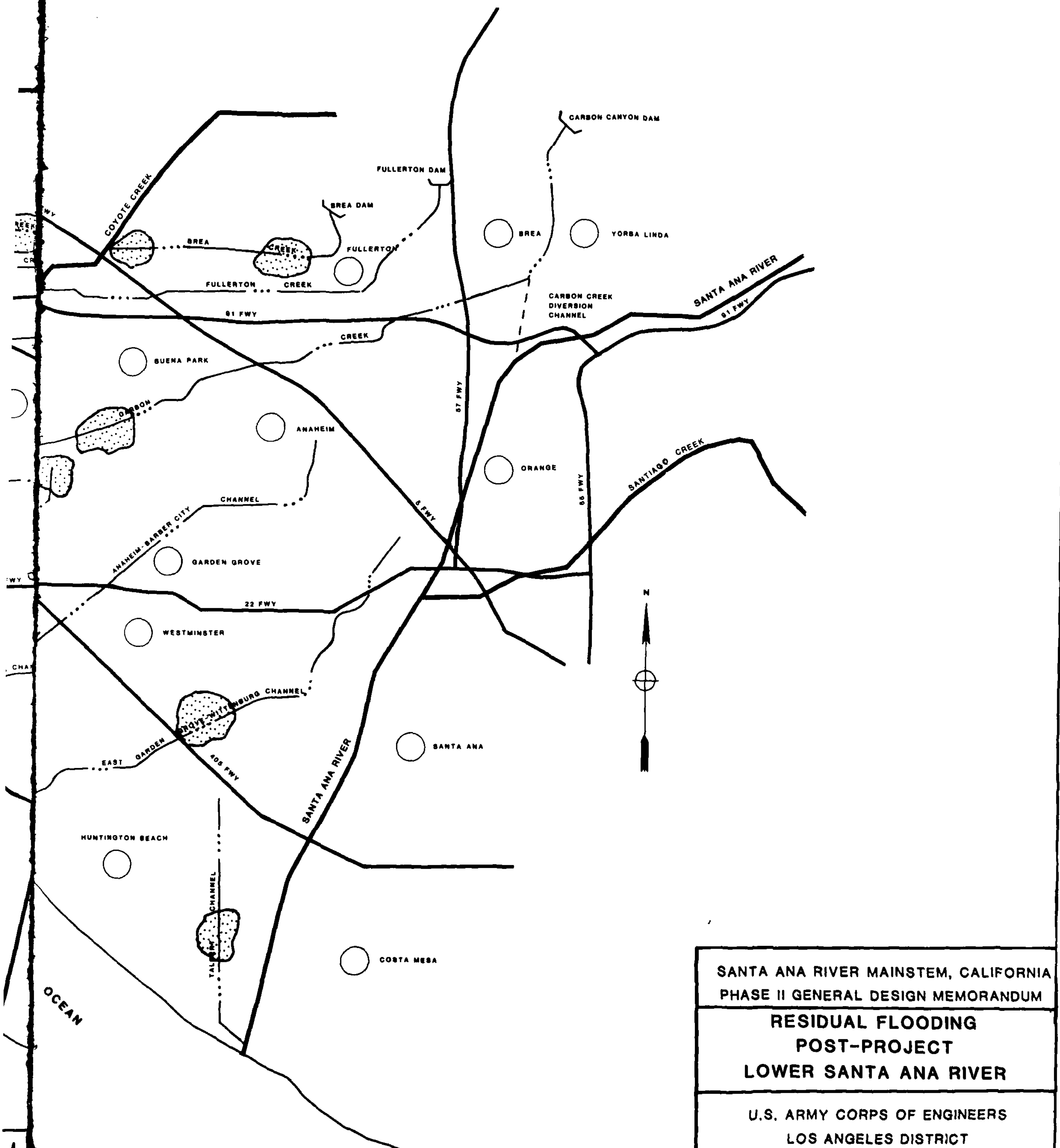
TYPICAL RELATIONSHIP OF COINCIDENT WATER SURFACE IN PRADO DAM WITH PEAK DISCHARGE AT INTERIOR DIKE

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

2



APPROXIMATE AREAS OF RESIDUAL FLOODING AFTER CONSTRUCTION OF SANTA ANA RIVER PROJECT

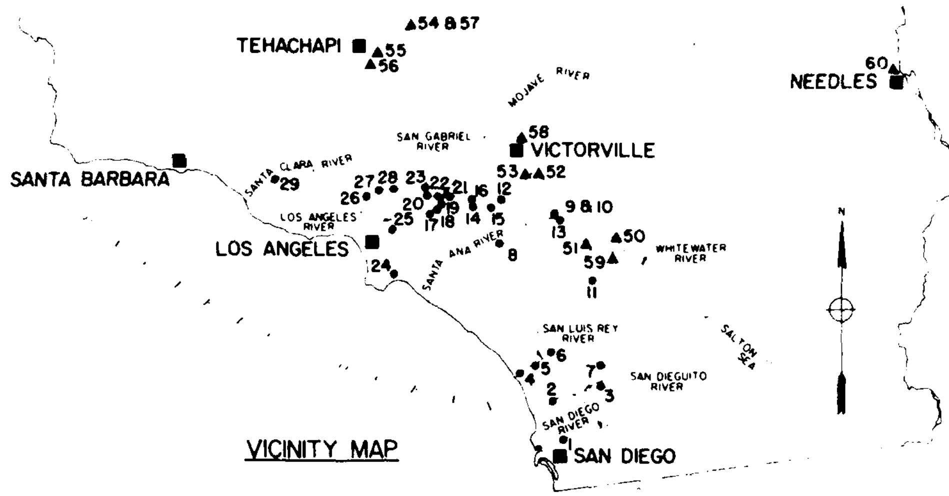


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

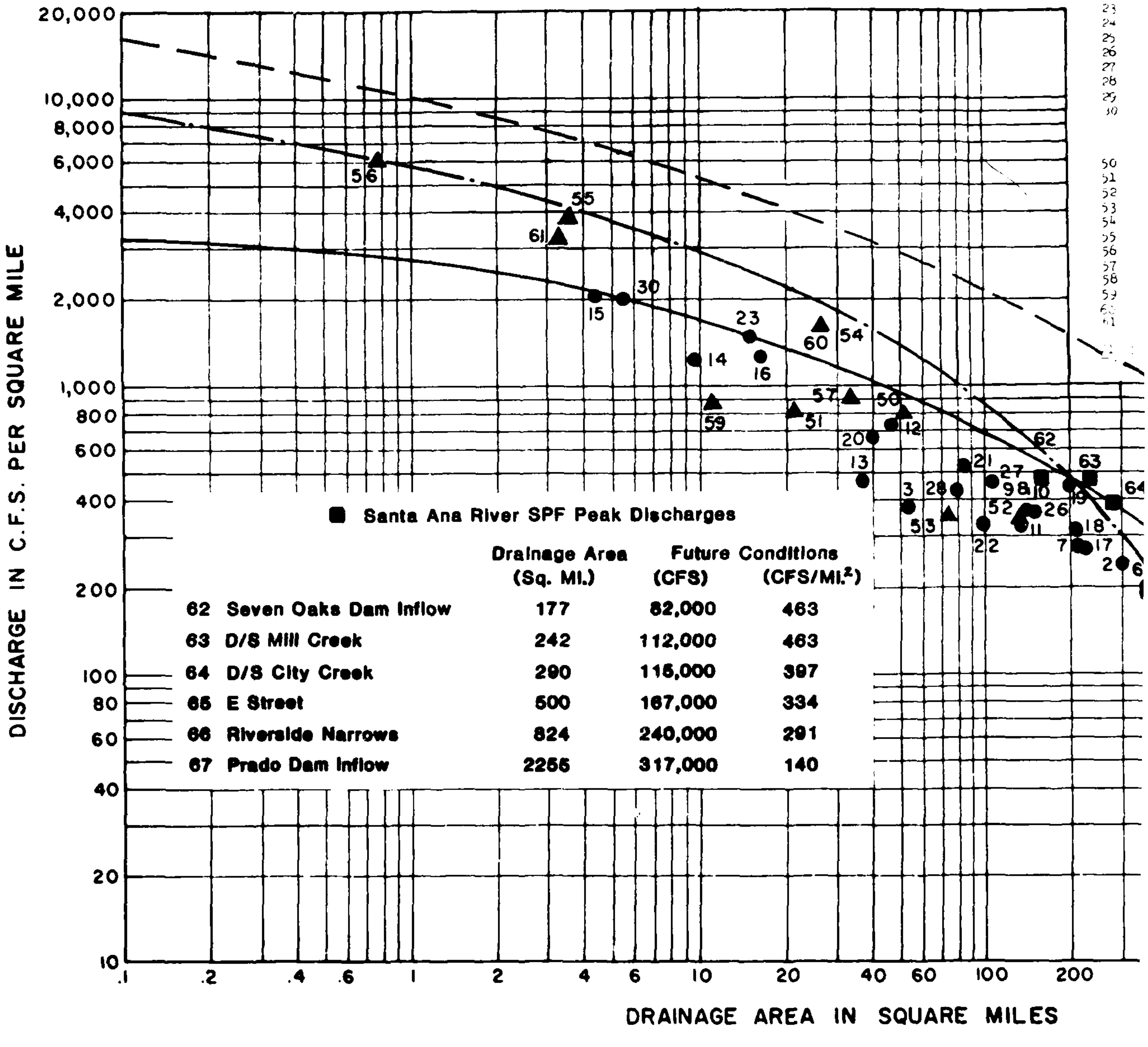
RESIDUAL FLOODING
POST-PROJECT
LOWER SANTA ANA RIVER

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

2



VICINITY MAP



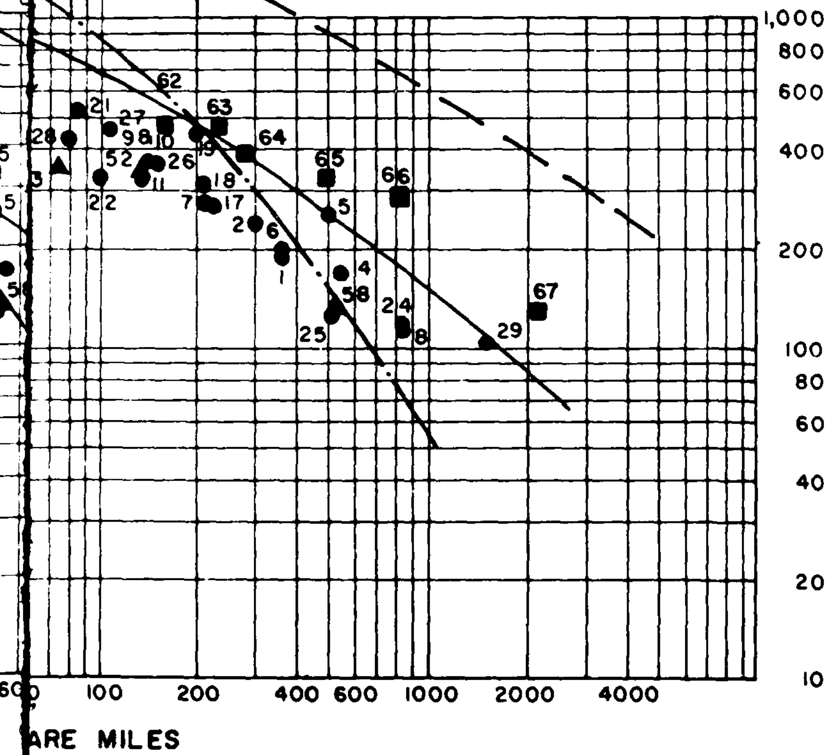
		Drainage Area (Sq. Mi.)	Future Conditions (CFS)	(CFS/MI.²)
62	Seven Oaks Dam Inflow	177	82,000	463
63	D/S Mill Creek	242	112,000	463
64	D/S City Creek	290	115,000	397
65	E Street	500	167,000	334
66	Riverside Narrows	824	240,000	291
67	Prado Dam Inflow	2255	317,000	140

NO.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
50
51
52
53
54
55
56
57
58
59
60
61

PERTINENT DATA

NO.	STREAM AND LOCATION	DRAINAGE AREA Square miles	PEAK DISCHARGE Cubic feet per second	DATE	AUTHORITY
	Southern California-Pacific Slope Basins				
1	San Diego River near Santee	377	70,200	27 Jan 1916	USGS WSP 447
2	San Dieguito River near Bernardo	299	72,100	....do.....	USGS WSP 426
3	Santa Ysabel Creek near Mesa Grande	53.9	21,100	....do.....	USGS WSP 426
4	San Luis Rey River at Oceanside	557	95,600	....do.....	USGS WSP 426
5	San Luis Rey River at Bonsall	512	128,000	23 Feb 1891	USGS WSP 447
6	San Luis Rey River near Pala	373	75,300	27 Jan 1916	USGS WSP 426
7	San Luis Rey River near Mesa Grande	209	58,600	....do.....	USGS WSP 426
8	Santa Ana River at Riverside Narrows	858	100,000	2 Mar 1938	USGS WSP 844
9	Santa Ana River near Mentone	144	52,300	....do.....	USGS WSP 844
10	.....do	144	53,700	23 Feb 1891	USGS WSP 447
11	San Jacinto River below North Fork near San Jacinto	141	45,000	16 Feb 1927	USGS WSP 844
12	Lytle Creek near Fontana	47.9	35,900	25 Jan 1969	USGS Calif 1969
13	Mill Creek near Yucaipa	38.1	18,100	2 Mar 1938	USGS Calif 1969
14	Cucamonga Creek near Upland	10.1	14,100	25 Jan 1969	USGS Calif 1969
15	Day Creek near Etiwanda	4.6	9,450	....do.....	USGS Calif 1969
16	San Antonio Creek near Claremont	16.9	21,400	2 Mar 1938	USGS WSP 844
17	San Gabriel River at Foothill Blvd	230	61,800	....do.....	USGS WSP 844
18	San Gabriel River below Morris Dam	211	65,700	....do.....	USGS Calif. 1963
19	San Gabriel River at San Gabriel Dam	202	90,000	....do.....	USGS WSP 844
20	San Gabriel River at Cogswell Dam	40.4	26,900	....do.....	USGS WSP 844
21	East Fork San Gabriel River near Camp Bonita	88.2	46,000	....do.....	USGS Calif. 1963
22	West Fork San Gabriel River at Camp Rincon	102	34,000	....do.....	USGS Calif. 1963
23	Devil's Canyon above Cogswell Dam	15.4	23,000	....do.....	/1
24	Los Angeles River at Long Beach	832	102,000	25 Jan 1969	USGS Calif. 1969
25	Los Angeles River at Los Angeles	514	67,000	3 Mar 1938	USGS Calif. 1963
26	Tujunga Creek below Hansen Dam	150	54,000	....do.....	USGS Calif. 1963
27	Tujunga Creek near Sunland	106	50,000	....do.....	USGS Calif. 1963
28	Tujunga Creek at Tujunga Dam (inflow)	81.4	35,000	....do.....	USGS Calif. 1969
29	Santa Clara River near Saticoy	1,595	165,000	25 Jan 1969	USGS Calif 1969
30	Fish Creek near Duarte	6.4	13,000	do	USGS Calif 1969
	Southern California-Interior Basins				
50	Whitewater River above Whitewater	51.4	42,000	2 Mar 1938	USGS WSP 844
51	San Gorgonio River near Banning	21.2	17,000	....do.....	USGS WSP 844
52	Deep Creek near Hesperia	137	46,600	....do.....	USGS WSP 844
53	West Fork Mojave River near Hesperia	74.8	26,100	....do.....	USGS WSP 844
54	Pine Tree Canyon 12 miles north of Mojave	35.0	59,500	12 Aug 1931	[illegible]
55	Cameron Creek near Tehachapi	3.59	13,500	30 Sep 1932	/2
56	Upper Willow Springs Canyon near Mojave	0.81	4,900	....do.....	[illegible]
57	Pine Tree Creek near Mojave	33.5	30,000	23 Aug 1961	USGS Calif. 1963
58	Mojave River near Victorville	530	70,600	2 Mar 1938	USGS Calif. 1963
59	Snow Creek near Palm Springs	11.0	9,500	Feb 1927	/3
60	Sacramento Wash near Needles	[illegible]	[illegible]	[illegible]	USGS
61	Little San Gorgonio Cr. near Beaumont	3.23	11,000	25 Feb 1969	USGS Calif. 1969

/1 Los Angeles County Flood Control District /2 Department [illegible] Water and Power, [illegible] /3 Coachella Valley Water District



LEGEND

- ● RECORDED OR ESTIMATED PEAK DISCHARGE-PACIFIC SLOPE BASINS.
- ▲ RECORDED OR ESTIMATED PEAK DISCHARGE-INTERIOR BASINS.
- — — — H. F. MATTHAI ENVELOPING CURVE OF MAXIMUM KNOWN FLOODS IN THE U.S.
- ——— C OF E ENVELOPING CURVE OF RECORDED OR ESTIMATED PEAK DISCHARGES FOR SOUTHERN CALIFORNIA COASTAL STREAMS.
- —·— C OF E ENVELOPING CURVE OF RECORDED OR ESTIMATED PEAK DISCHARGES FOR SOUTHERN CALIFORNIA DESERT STREAMS

SANTA ANA RIVER MAINSTEM, CALIFORNIA

PHASE II GENERAL DESIGN MEMORANDUM

ENVELOPING CURVES OF PEAK DISCHARGES

STREAMS IN SOUTHERN CALIFORNIA

U.S. ARMY CORPS OF ENGINEERS

LOS ANGELES DISTRICT

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